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The First Annual SERDP Symposium was convened to emphasize transfer of SERDP accomplishments to the user communities. These abstracts, which represent the 58 technical papers and 96 exhibits/posters presented at the Symposium, illustrate why the almost 500 symposium attendees considered this kickoff effort to be a resounding success. Upon reading these abstracts, I think you will find that SERDP has already produced a wide variety of high-impact, high profile results that will greatly assist the Defense sector's mission readiness.

As SERDP matures, these contributions will be even more significant. As DoD's corporate environmental S&T Program, SERDP is poised to continue and accelerate the development of these mission critical, environmental technologies into the next century.

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Improving Mission Readiness through Environmental Research

PROCEEDINGS

1995 SERDP Symposium

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DoD EPA DOE **SERDP**

Strategic Environmental Research and Development Program

Improving Mission Readiness through Environmental Research

May 31, 1995

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DoD/National Environmental Technology Demonstration Program National Test Locations

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The Tri-Service and EPA test locations of the D/NETDP comprise a network of well characterized demonstration sites at DoD installations for applied research, demonstration, and evaluation of promising cleanup and characterization technologies. Together, the sites afford the opportunity for developers to compare and confirm technology performance under known field conditions.

The hydrogeochemical and contaminant mixture conditions at the D/NETDP locations have been well characterized as a result of the Installation Restoration Program and more focused site reconnaissance and characterization efforts. Many individual contaminated sites for anticipated demonstration exist at most of the test locations so that realistic technology / hydrogeochemical / contaminant conditions can be provided for the evaluations.

The D/NETDP was established in order that principal investigators and project officers from DoD, DOE, and EPA laboratories could easily find sites and support facilities for applied research projects and technology demonstrations. The D/NETDP will provide the following support services and facilities:

- infrastructure for applied research and remediation technology demonstrations
- infrastructure for site characterizations and monitoring technology demonstrations
- permit processing for demonstrations
- maintenance and on-site support of infrastructure facilities
- on-site analytical laboratory facilities sufficient for field screening and real-time process control purposes
- limited sample handling, preservation, and storage facilities to facilitate off-site analysis
- establish a thorough long-term historical site characterization database equivalent to a remedial investigation survey on environmental conditions to provide high density information, and
- support for public relations interface.

In accordance with the D/NETDP, a coordinated Tri-service effort, the Navy is to support applied research and demonstration of ex-situ and in-situ fuel hydrocarbon cleanup and characterization technologies. The Air Force is to support the research and development, tests, and field evaluation of fate, transport and limits to cleanup of dense nonaqueous phase liquids (DNAPLs), e.g., chlorinated solvents, in ground water, gas and soils. The Army is to support research and development, tests, and field treatment and cleanup technology evaluation on soil, sediments and ground water contaminated by waste explosives materials produced during the production, storage, and disposal. The Army is also responsible for remedial research investigations and technology demonstrations of heavy metal contaminants. The EPA effort is to support research through field demonstrations of soil and

DoD/National Environmental Technology Demonstration Program National Test Locations (cont'd)

water remediation technologies of diverse organic contaminates. The lead Tri-service and EPA organizations for coordinating these efforts are:

- Naval Facilities Engineering Service Center, Port Hueneme, CA
- U.S. Army Environmental Center, Aberdeen Proving Ground, MD
- U.S. Air Force, Armstrong Laboratory, Tyndall AFB, FL
- U.S. Air Force, Environmental Management Office, McClellan AFB, CA
- U.S. EPA, Headquarters, Washington, DC, in cooperation with the University of Michigan
- U.S. EPA, Environmental Monitoring Systems Laboratory, Las Vegas, NV

Accelerated Tri-Service Characterization and Analysis Penetrometer System Environmental Sensor Development and Demonstration Program

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The Site Characterization and Analysis Penetrometer System (SCAPS) has proven to be a rapid and cost-effective means to collect data and to map subsurface geophysical and environmental contaminant sites. Currently fielded SCAPS units are capable of characterizing sites that are suspected to contain a wide range of petroleum, oil, and lubricant (POL) contaminants, and have a limited capability to detect radioactive wastes. A number of Army, Navy, and Air Force researchers have been pursuing the development of additional contaminant detection capabilities for SCAPS. Recently, the Strategic Environmental Research and Development Program (SERDP) funded a project to combine the efforts of the Tri-Service Researchers and to accelerate the development, testing, and demonstration of new SCAPS technologies. These technologies include new sensors, samplers, and data processing software/hardware systems to extend SCAPS capabilities to sites contaminated with explosives, metals, and volatile organic compounds. In addition, the SERDP project is accelerating the development, testing, and demonstration of improved sensors to enhance existing SCAPS capabilities to detect POL and radioactive wastes. This paper presents an in-depth description of the various technologies that are being developed under this program, and includes laboratory and field data that support performance estimates for the SCAPS sensors. The paper also describes the extensive field testing and demonstration program designed to validate and field the new SCAPS capabilities in minimum time, and the various efforts underway to license and commercialize the emerging SCAPS technologies. Included in the poster presentation are descriptions of the following technologies: a. The Army-developed electrochemical sensor probes for detecting explosives contaminants in soils; b. The Army/Navy-developed Laser Induced Breakdown Spectroscopy (LIBS) system for detecting metals in soils; c. The Navy-developed Fiber Optic Raman Sensor (FORS) prototype for detecting VOC's in subsoil and groundwater; d. The army-developed multiport and thermal-desorption samplers for detecting and sampling VOC's; e. The Air Force-developed tunable Laser Induced Fluorescence (LIF) system for enhanced POL detection; and f. The Tri-Services developed data processing and visualization system to support the emerging SCAPS sensor technologies.

Ex-Situ Bioremediation of Fuel-Contaminated Soil at the Navy National Test Site, CBC Port Hueneme

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The Naval Facilities Engineering Service Center is currently operating an ex-situ bioremediation system at the Navy National Test Site at CBC Port Hueneme. Fuel-contaminated soil excavated from leaking underground fuel tanks (LUFTs) are brought to a centralized treatment facility for biological treatment. The treatment cell capacity at the Port Hueneme site is approximately 500 cubic yards. The treatment facility is designed to maintain optimal conditions (e.g. oxygen, soil moisture, nutrients, pH, salinity, etc.) to enhance indigenous microbial growth for rapid degradation of fuel contaminants.

A biotreatability study was conducted in the laboratory to determine optimal operating conditions to be maintained in the field. From soil permeability and porosity data obtained at the site, a computer airflow model was employed to identify oxygen deficient zones in the soil pile. Aeration system components are sized based on this model. Optimal conditions are maintained in the field by monitoring critical parameters through use of instrumentation, soil and leachate sampling and sample laboratory analyses. Hydrocarbon Degradation is also being monitored with recalcitrant markers and fuel degradation component analyses. In addition, heterotrophic and hydrocarbon degrader microbes present in the soil and leachate are being monitored. Nutrients and moisture are added to pile during construction based on treatability study recommendations. A Drip irrigation system, leachate recycling system, and moisture monitoring instrumentation allows accurate metering and adjustment of soil pile moisture. Thermistors have also been installed for soil pile temperature profiling efforts and input to pile heat transfer calculations. A transparent cover is used for solar heat collection and for visual observation of the drip system. Starting diesel contaminant concentrations in the soil are as high as 4,000 ppm and cleanup level requirements have been specified at 250 ppm. The remedial period is expected to take from 3 to 4 months.

Treatment of Process Off-Gases Contaminated With TCE Using In-Situ Soil Based Aerobic Bioreactors

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Many DoD sites, and in particular fire protection training areas, have relatively low concentrations of chlorinated solvents (such as TCE) dissolved in a larger mass of NAPL petroleum hydrocarbons (such as JP-4 jet fuel). If these sites have a significant vadose zone, and the concentration of chlorinated solvents is not high enough to be toxic, the vadose zone can be used as an in-situ bioreactor for destruction of the chlorinated solvents while the fuel is destroyed by bioventing. The waste fuel serves as the substrate for the co-oxidation of the chlorinated solvents.

A fire protection training pit at Plattsburgh AFB, New York was mapped by more than seventy penetrations with a cone penetrometer. The penetrometer was equipped with a lasar fluorescence spectrometer that measured the concentration of JP-4 as a function of depth of penetration. At selected locations, continuous cores were taken through a conventional hollow stem auger, and the cores extracted and analyzed by GC/mass spectrometry. This information was used to benchmark the fluorescence return. Core samples were subjected to a laboratory treatability study simulating the exchange of eighty pore volumes of air.

The site contains approximately 122,000 gallons of residual JP-4, confined between 10 and 50 feet below grade. Most of the residual fuel was located up-gradient and to the side of the spill, and not immediately down-gradient as would be expected. The highest concentrations encountered were about 3% TCE in the JP-4. The treatability study indicated that co-oxidation was possible, with a 91% reduction in TCF concentration due to volatilization, and a 99.5% reduction due to volatilization and biological co-oxidation.

The Air Force intends to use the site-characterization data to install a soil vacuum extraction system that will maximize the residence time of air and allow maximum biological co-oxidation of TCE in-situ.

Enhanced Anaerobic Degradation of Jet Fuels in Groundwater

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Although aerobic bioremediation has been successfully applied to fuel-contaminated aquifers, difficulties relating to aquifer plugging and oxygen mass transport are often encountered. Studies have shown that alternate electron acceptors such as nitrate, in place of oxygen, can be utilized by microorganisms resulting in anaerobic biodegradation of organic compounds. A nitrate-based bioremediation field study is being conducted at a groundwater fuel-contaminated site located at Eglin AFB Florida. The objectives of this research are to provide a thorough site characterization to delineate contaminant distribution and microbial activity in the aquifer, conduct field and laboratory tests to provide design parameters for pilot-scale treatment system, and design, construct, and operate a treatment system to provide a direct comparison of the effects of recharge with and without nitrate amendments for a 14 month period. Core and water data will be used to compare the extent of benzene, alkylbenzene and JP-4 degradation in the two treatment plots. Changes in microbial populations and sediment toxicity will be evaluated as a result of nitrate-based bioremediation. This paper briefly describes the site characterization, tests conducted to determine the potential for nitrate-based bioremediation, design parameters of a field treatment system and interim performance evaluation.

Groundwater Cleanup of Organic Contaminants (TCE/PCE) Using Methanotrophic Bioreactors

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Hybrid, field scale, anaerobic-aerobic, fluidized bed GAC bioreactors (FBR) were used to evaluate and optimize on site, methanotrophic treatment technology (MTT) of a ground water plume containing trichloroethylene and tetrachloroethylene at the Dept. of Energy's Savannah River Site. Each FBR is a skid-mounted, 2'x40' column (Envirex) on a curbed concrete slab to provide containment. This demonstration of ground water cleanup is sponsored by the Strategic Environmental Research and Development Program (DOD-EPA-DOE).

Contaminated ground water is pumped directly to FBR #1 which is operated in an anaerobic mode, i.e., optimized for reductive dechlorination of TCE/PCE to dichloroethylene (DCE) and vinyl chloride (VC). FBR #2 is optimized for aerobic methanotrophic oxidation (epoxide formation) of DCE, VC, and any residual TCE. Influent raw water is combined with recycled effluent water which has passed through FBR #1; the total inflow raw water of 3.0-5.0 gpm and a maximum of 3.0 ppm TCE is mixed with FBR #1 effluent water @ 1.0 ppm TCE and pumped into FBR #1. Approximately 3-5 gpm of effluent from FBR #1 is mixed with 24 gpm of effluent waters from FBR #2, and split to receive air and CH_4 where it is pumped to FBR #2. The effluent from FBR #2 goes to final treatment, continuous-backwash granular filter to remove suspended solids prior to entering a holding tank.

This hybrid methanotrophic treatment technology provides a faster startup, more rapid and complete degradation (maximum degradation rates surpass those of a single reactor system) with less toxic byproducts and is simple, easy to use and cost effective. This 2 stage FBR recirculating system operates at a maximum flow rate of 5 gpm while reducing TCE and associated organic contaminants from 3 mg/L to <0.001 mg/L.

Application of Bioslurping Technology at Naval Fuel Remediation Sites

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Bioventing provides for rapid biodegradation of both high and low volatility fuels in vadose zone soils by satisfying the high oxygen demand with large quantities of molecular oxygen, as provided by forced aeration of subsurface soils. However, many Naval field sites have liquid fuel residing on the groundwater table. In such cases biodegradation of the immiscible fuel compounds (LNAPL) can be a very slow process because bioemulsification and bioavailability are impeded. Bioslurper systems are designed to recover LNAPL via vacuum-enhanced pumping, while simultaneously promoting the remediation of vadose zone soil contamination via bioventing. Many wells can be connected to a single low-power above-ground vacuum pump, and fuel removal from depths of over 40 ft has been demonstrated. LNAPL recovery is enhanced by a vacuum-induced gradient, which increases fluid flow into extraction wells. Because the vacuum gradient appears to be primarily horizontal, through soil planes having higher permeability, the zone of influence and ability to remove LNAPL from lower permeability soils is much greater than with conventional dual pump systems. Bioslurping has been ongoing at NAS Fallon, Nevada, for over two years and has been initiated at Marine Corps Base Hawaii. The sites have low volatility JP-5 jet fuel on the groundwater table. LNAPL recovery rates from low permeability soils at Fallon have ranged from 15 to 60 gal/day, with an average of 45 gal/day, pulling 4 to 12 inches of mercury vacuum. LNAPL discharge rates have remained relatively uniform during the bioslurper demonstration but appear to be directly correlated with applied vacuum. Fuel contaminant discharge from the bioslurper system for LNAPL, vapor and aqueous component are 97%, 2.7% and 0.3%, respectively. Groundwater extraction rates have ranged from 0.3 to 2.3 gpm, with the rate varying directly with seasonal fluctuation in groundwater elevation. Based on periodic soil gas analyses from 90 isolated soil gas sampling points, bioslurping appears to satisfy the O_2 limitations in the contaminated soil profile. However, in situ respirometry testing and visual observation have indicated that LNAPL bioemulsification and biodegradation are nil within the test site but are at moderate rates only 100 ft outside the plot, where monoaromatic compounds found in gasoline (BTEX) have been detected in the groundwater. Causes for the differences in respiration rates are being determined further through toxicity and microcosm evaluations.

Evaluation of Semipermeable Membrane Device (SPMD) as a Passive In Situ Concentrator of Military Organic Chemicals in Water.

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Worldwide, the Department of Defense (DoD) has nearly 1,900 installations on which are located about 17,000 identified sites that will require some level of remedial action. Many of these sites potentially impact groundwater, wetlands, streams, and other aquatic ecosystems. The contaminants that may impact these aquatic resources range from explosives to petroleum related residues to pesticide waste. Indeed, many DoD waste sites involve the past production, disposal, and use of pesticides (e.g. Rocky Mountain Arsenal). Because of their widespread distribution, environmental persistence, and propensity to bioaccumulate, the organochlorine pesticides (OCs) represent a group of contaminants of special interest. In addition, many of the OCs are suspected "environmental hormones" and have been implicated in the gender alteration in fish and wildlife and the increased incidence of cancer in humans. The semipermeable membrane device (SPMD) technology is particularly well suited for defining the presence of bioavailable organic contaminant residues. Because the transport of the hydrophobic contaminant through the SPMD is phenomologically similar to transport through biomembranes, the sequestration of organic contaminant residues by the SPMD mimics the uptake and bioconcentration of contaminants by aquatic organisms. Consequently, the SPMD approach provides a means of defining exposure of aquatic organisms to organic contaminants and a method for determining the ambient concentrations of bioavailable organic contaminants in a broad array of aquatic systems. This paper describes the operational aspects of the SPMD, deployments under environmental conditions, summarizes the kinetic uptake studies conducted to date, and presents preliminary data from model development for calculating ambient waterborne organic contaminant concentrations.

Treating Contaminated Groundwater Using a Peroxone Oxidation Pilot System

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The Department of Defense has over 6,000 sites that have been contaminated from past activities pertaining to national defense. Diisopropylmethylphosphonate (DIMP) is a by-product of nerve agent manufacture. It has been detected at various locations at the Rocky Mountain Arsenal including the north Boundary Treatment System, which is a groundwater capture and treatment system currently using activated carbon. Unfortunately, DIMP does not have a high sorption affinity to activated carbon; thereby, making carbon adsorption an expensive technique for removing DIMP from the Arsenal groundwater. However, at this time, there are few options available to the Department of Defense that are both technically and economically feasible for removing DIMP from groundwater influents. The U.S. Army Engineer Waterways Experiment Station was tasked by Rocky Mountain Arsenal to investigate using advanced oxidation processes (AOPs) for removing DIMP from the North Boundary groundwater influent. AOPs investigated at the bench scale were UV/hydrogen peroxide, UV/ozone, and peroxone (dark reaction between ozone and hydrogen peroxide). Peroxone was found to be kinetically similar to the two more traditional UV based AOPs. However, the economics of peroxone appeared to be superior to those of the two UV based AOPs.

Based on positive bench study results, researchers from the USAE Waterways Experiment Station performed an on-site pilot study using a pilot scale peroxone system at Rocky Mountain Arsenal to assess the feasibility of using peroxone to remove DIMP from the groundwater influent of the North Boundary Treatment System. The system consisted of four 14 foot tall glass ozone contact columns (plumbed in series), an ozone generator, and system of on-line process analyzers coupled to a 486 computer used for both system operations and data logging activities. Various flowrates ranging from 1 to 2.5 gpm were investigated using various oxidizer concentrations. Results indicated that peroxone was effective in removing DIMP (initially 70 ppb) from the ground water influent. Hydraulic residence times to remove DIMP to below detection limit values (0.5 ppb) were dependent on the relative ozone-to-hydrogen peroxide dosages. A constant 2% ozonated air sparged system with 100 ppm hydrogen peroxide appeared had the best removal kinetics of all the systems evaluated by removing DIMP to below detection limit levels within 30 minutes. Increasing the hydrogen peroxide dose to 500 ppm and keeping the same ozone dose had a detrimental impact on system performance due to scavenging of hydroxyl radicals by the excess hydrogen peroxide. This paper will focus on the various peroxone systems evaluated during both the bench and pilot study with primary emphasis on the pilot results. Removal of DIMP and other contaminants detected at much lower levels (chloroform, nitrosoamine, and pesticides) will be presented along with an engineering assessment of potential application of peroxone.

Developing Biotreatment Technologies for DoD Site Restoration

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The Department of Defense (DoD) has numerous sites that have been contaminated with organic pollutants due to past military activities. The most prevalent contaminants that have been detected at DoD sites are polychlorinated biphenyls (PCBs), explosives, chlorinated solvents, polycyclicaromatic hydrocarbons (PAHs), and petroleum fuels. The cost of remediating these sites using current technologies will be astronomical. Biological processes is viewed by many experts to be a promising alternative treatment options for remediation of wastes such as those found at DoD sites.

As an attempt to reduce the costs of remediating the over 6,000 sites that the DoD must cleanup, the Federal Integrated Biotreatment Research Consortium has been formed under funding from the SERDP. This consortium brings together some of the leading experts in the field of biological treatment from federal agencies such as the U.S. Army, U.S Navy, U.S. Air Force, USEPA, DoE, and a university research group composed of Michigan State University, University of Michigan, and Howard University. The objectives of the Consortium is to further develop and field promising biotreatment processes. Research subjects include PCBs, PAHs, explosives, chlorinated solvents, and reactor development/design improvements. This presentation will focus on highlighting various processes under development with particular emphasis placed on field readiness.

Encapsulated Bacteria for In-Situ PAH Bioremediation.

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Soils and sediments at naval refueling facilities are often contaminated with petroleum products that are classified as environmental waste. Physical removal and subsequent detoxification of these soils and sediments is expensive and often disruptive to naval operations. Using microencapsulated bacteria to affect in situ detoxification of hazardous waste compounds is a potential low-cost alternative to excavation and off-site treatment of contaminated soils. This paper describes the development of a microencapsulation system and the testing of this treatment strategy in soil and sediment microcosms. Petroleum-degrading strains of bacteria were encapsulated using calcium alginate or polyvinyl alcohol in a technique designed to optimize viability and activity of the cells. Nutrient and oxygen sources were co-encapsulated with the bacteria to enhance petroleum degradation rates. In addition, compounds and conditions that inhibit petroleum degradation were identified. Understanding such parameters reduces the risk that the treatment strategy will be used in situations where the likelihood of success is low. This approach allows us to develop in situ treatment train strategies that optimize the effectiveness of the various bacterial strains.

In Situ Bioremediation of Fossil Fuel and Efficacy of Monitoring

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Contamination of soil, sediment and waters by fossil fuel-based contaminants represents the world's largest environmental problem. Given the scope and magnitude of these environmental contamination problems, bioremediation often represents the only economically feasible solution. The objective of this project is to transition cost-efficient technologies for in-situ bioremediation and on-line performance monitoring to the end user, through a series of field demonstration programs. To accomplish this a multidisciplinary team of scientists and engineers has been formed to develop and refine innovative in-situ bioremediation strategies through two unique thrust areas: development of techniques for measuring effectiveness of bioremediation treatments and integration of two technologies for enhancement of PAH degradation in the field. Monitoring is being done by natural abundance stable carbon isotope ratio analysis of CO2 using a GC/IRMS and the test bioremediation strategy utilizes a ground water circulation device with an integrated bioreactor. Laboratory studies in a large-scale mesocosm are being done to model and test the efficacy of monitoring and biodegradation strategies. System capabilities include the measurement of biodegradation rates, identification of catabolic intermediates, assessment of formation of toxic end-products, and performance of mass balances of the contaminant under controlled and defined conditions. Similar studies will be conducted with field samples to define the fate and effect of parent compounds and biotransformation products for mass balances. Field work to validate the monitoring technique will be conducted at five test sites employing five different bioremediation strategies.

Toxicology and Human Health Risks

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The Air Force has rated Trichloroethylene (TCE) in the top five chemicals of concern in their Superfund sites. The Agency for Toxic Substances & Disease Registry rates TCE among the top ten contaminants in Superfund sites nationwide. The current remediation level of 5 ppb is extremely difficult, and costly, to achieve. TCE remediation levels are based upon its carcinogenic potential, as evidenced in experiments using mice. Risk assessment is based on a paradigm developed for chemicals which cause mutations. TCE, however, is thought by most cancer researchers to fall into a category of carcinogens which act through promotion (the amplification of mutations already present). Several alternative risk assessment procedures are more appropriate for promoters. The Armstrong Laboratory Tri-Service Toxicology approach to this research opportunity is to build a strong scientific basis for the reevaluation of TCE remediation levels. Studies underway are aimed at: (1) elucidating the biological mechanisms underlying TCE carcinogenesis, (2) creating robust pharmacokinetic and pharmacodynamic models which will facilitate extrapolation of rodent data to man, (3) limited exposure studies in human volunteers, and (4) employing alternative risk assessment methodologies.

Hazard Assessment Techniques & Biomonitoring Technology

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The assessment of potential hazards posed by complex environmental contamination drives the cleanup decisions made by Federal risk managers. From site prioritization to remediation efficacy demonstration to long term monitoring required by Federal law, the question of how we decide what is "clean" is the central determinant in decisions affecting the annual expenditure of billions of dollars. The use of biological models to integrate exposure to complex chemical mixtures in the environment and then determine the actual hazard that the contamination may pose is the subject of this presentation. Improved hazard assessment models for neurotoxicity, acute toxicity, mutagenicity, chronic toxicity, developmental and reproductive toxicity, and chemical disposition are being developed through a multi-laboratory R&D consortium. The data developed from these models will be used in an integrated environmental assessment model which will be transitioned to risk managers at installations involved in remediation and compliance activities.

Mobile Underwater Debris Survey System (MUDSS)

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The Coastal Systems Station (CSS) in conjunction with the Jet Propulsion Laboratory (JPL) has been awarded a Strategic Research and Development Program (SERDP) task to demonstrate a mobile underwater debris survey system. This effort is targeted for use in the cleanup of Formerly Used Defense Sites (FUDS). Of the more than 900 FUDS which require some measure of cleanup, more than 50 are estimated to need an underwater explosive waste survey capability which currently does not exist. The CSS and JPL have combined their technological expertise to formulate a system with multiple sensors, an aided target recognition processor, and visualization algorithms which will provide significant capability for the underwater explosive ordnance detection problem. This MUDSS Dual-Use initiative leverages both mine countermeasures technologies developed by CSS for the Office of Naval Research and processor and visualization technologies developed by JPL for the National Aeronautics and Space Administration. Potential users of the system include the Army Environmental Center, the Army Corps of Engineers, and the Navy mine countermeasures program (through the spin-on of fusion and visualization capabilities). This paper describes the program plan for developing MUDSS and demonstrating its capabilities.

Silica Fiberoptic Probe for Site Characterization

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The objective of this project is to apply the unique characteristics of an all-silica fiberoptic sensor to the varied analytical problems of the Department of Defense. This probe, developed for a high-temperature molten salt (750°C) application, is made from only silica; no epoxies, cements, etc. are used in its construction. It therefore has the chemical, temperature, and radiation stability of silica. Further, since it is essentially a silica rod, its head can be easily modified geometrically to accommodate specific analytical applications. The probe will be described, and currrent and future unique applications will be presented.[1]

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Field Portable FTS Fiber Optic VOC Sensor

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This is a 1994 applied research (6.2) program sponsored by the Strategic Environmental Research and Development Program (DOD-EPA-DOE). The lead organization is the Wright Laboratory, Avionics Directorate, Laser Sensor Technology Laboratory. The objective of this program is to develop an instrument to detect and qualitatively measure the presence of volatile organic compounds (VOCs) in soil at hazardous waste sites and long term compliance monitoring stations. This research will concentrate on a VOC demonstration set consisting of benzene, toluene, and trichloroethylene. Such a sensor should reduce soil collection burdens and mitigate soil property variances by rapid preliminary characterization of hazardous waste sites through near-real-time, in-situ detection and identification of VOCs. Our approach is based on the development of a miniaturized Fourier Transform Spectrometer (FTS) and integrated detector/processing technologies. These are true dual-use technologies which are being developed concurrently to support both the environmental application of a field portable VOC sensor, as well as a wavelength identification subsystem in military laser warning receivers.

We will investigate the feasibility of a hardened instrument package that includes a fiber optic Raman probe coupled to the miniaturized spectrometer. The spectrometer is based on a solid common-path interferometer and a unique solid-state detector that provides optical detection and spectral processing on a single integrated circuit. The effort will build upon current Raman and/or surface enhanced Raman spectroscopy (SERS) techniques for sample interrogation and identification. Laboratory experiment and the development and characterization of a breadboard prototype will demonstrate the detection concepts. The results will be quantitatively compared to current measurement techniques. The prototype's hardened FTS and monolithic FT chip will also be tested in military applications such as laser warning receivers, identification friend or foe (IFF) systems, or optical communications configurations.

This paper will present the concepts and goals of the program and outline its technical approach. The preliminary results of the FTS hardening and miniaturization effort will also be presented.

Removal and Encapsulation of Heavy Metals from Ground Water

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Heavy metals such as lead, chromium, cadmium, mercury, etc. are detected in ground water on many Federal Facility sites. This applied research problem will assess the feasibility of using low cost, high capacity sorbents for cost effective removal of heavy metals from ground water, with subsequent residual encapsulation in a polymer to prevent further release to the environment.

Promising natural based sorbents include material such as xanthates, sawdust, peat moss, chitin, etc. Functional groups can be added to these sorbents for higher capacity. Sorption isotherms will be developed to determine which sorbent has the highest capacity for a combination of heavy metals. These sorbents also have application to the funnel and gate system concept for in situ ground water treatment.

Using an encapsulation polymer for the sorbed heavy metal matrix allows for either permanent disposal or temporary storage. This residuals management technique, as opposed to cement solidification or vitrification techniques, offers resource recovery of valuable metals (such as chromium or mercury) removed from ground water and stored within the polymer. The polymer can be separated from the sorbent in the future if metal recovery is desired.

Polyethylene and a copolymer, developed specifically for this project, will be evaluated for sorbent compatibility and environmental durability. Polyethylene has been shown to be a very stable polymer for waste encapsulation. The combining of two polymers (copolymer) will exhibit the desirable properties of each polymer for environmental durability. In addition, certain copolymers can be used to protect surplus military equipment.

Integrated Characterization Program Combining DOE and DOD CPT Sensor Technologies

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Defining the nature and extent of subsurface chemical contamination is a costly and time-consuming process at sites requiring remediation. Although determining the current position of subsurface contaminants is important, obtaining the information necessary for predicting future contaminant transport may be of even greater importance. Fate and transport modeling for risk- based assessments and planning cost-effective remediation strategies both require this type of information. With the advancement in the design and use of cone penetrometer testing (CPT), most emphasis has been placed on development of chemical sensors aimed at delineating contaminant plumes. Little work has been done in terms of measuring physical properties, such as volumetric water content and hydraulic conductivity, which control the rate and extent of contaminant migration. In this project we are combining CPT sensors to provide a method that utilizes in situ determination of soil physical properties to predict contaminant transport variations. This includes CPT sensor development on new optical based imaging systems and time domain reflectometry (TDR) sensors. These new sensors will determine grain size distributions and volumetric water contents that will be used to predict hydraulic properties and transport variations based on laboratory calibrated relationships. In addition to predicting contaminant transport, the physical properties measured by these CPT sensors are essential variables in evaluating the design and performance of bioremediation and soil venting systems. The benefits of this project include a continuous, rapid method for in situ measurement of the physical properties controlling contaminant transport, plus enhanced stratigraphic control and matrix calibration information for other CPT chemical sensors.

Air-Sparging and In Situ Bioremediation Research at Picatinny Arsenal, New Jersey

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Trichloroethylene (TCE) is the dominant constituent in a contaminant plume in ground water in the unconfined aquifer at Picatinny Arsenal, Morris County, New Jersey. Because the plume is anoxic, natural rates of degradation of TCE are very low. The U.S. Army has initiated an interim action to contain and treat the plume. However, because desorption of TCE from aquifer sediments is slow, costly pump-and-treat operations could continue indefinitely. Similar scenarios exist throughout the country at countless industrial and military sites.

The U.S. Geological Survey, in cooperation with the Department of DefenseStrategic Environmental Research and Development Program, (SERDP) is conducting a study to develop a cost-effective strategy for removing TCE and related chlorinated solvents from ground water through the use of air sparging combined with cometabolic biodegradation. During sparging, air injected into the ground water physically removes contaminants by volatilizing them. Because injected air also increases the available oxygen, it may be possible to enhance aerobic biodegradation by adding methane to the sparge gas. The addition of methane and oxygen to the ground water is likely to encourage the growth of methanotrophic bacteria, which have the ability to degrade TCE through a cometabolic process. In order to evaluate the effectiveness of such a remediation system, methods need to be developed for quantifying both physical and biological removal rates.

Laboratory methods to quantify removal rates are being developed with the use of contaminated sediments from the site. Physical and biological removal rates will be quantified separately to evaluate the effectiveness of the microbial enhancement. Batch sparge experiments are being used to quantify physical removal. Microcosms and flow-through columns are being used to evaluate biodegradation rates based on stoichiometric relations between oxygen and methane consumed, and carbon dioxide produced. Laboratory microcosm experiments containing sediment and water from the site demonstrate that the growth of methanotrophic bacteria can be enhanced by the addition of oxygen and methane. Evidence for the cometabolic degradation of TCE has been observed. The microcosms currently are being used to determine the concentrations of methane and oxygen that will optimize biodegradation of TCE. Results of these experiments will be applied to field-scale air-sparging experiments at the arsenal.

The initial distributions of volatile organic compounds, geochemical species, and microbial communities at the Picatinny Arsenal field site have been determined. TCE at the site resides mostly within a sandy silt layer between the depths of 40 and 60 feet. More than half the detected TCE is sorbed to the sediment. Measurements of viable and methanotrophic organisms indicate that both classes of microorganisms are present in very low numbers. Preliminary sparging experiments at the site have just begun. Results of ground-water sampling and geochemical modeling indicate that air sparged into the anoxic ground water will cause minor amounts of iron and manganese to precipitate; however, this is not likely to interfere with sparging operations. The application of stoichiometric relations determined in

the laboratory to the sparging experiments at the field site is expected to provide a means for evaluating the effectiveness of enhanced cometabolic biodegradation as a remediation strategy.

Continuous Flow Immunosensor for the Detection of Groundwater Contaminants

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This project involves the development of an inexpensive, field-portable device which is able to detect environmental pollutants, such as polychlorinated biphenyls (PCBs) or explosives (TNT, RDX, etc.), in groundwater. The continuous flow immunosensor was developed at the Naval Research laboratory and has previously been shown to be effective at detecting drugs of abuse. Our sensor is designed to have many advantages over current analytical detection methods (such as gas chromatography with mass spectral detection), including: low cost (can run many negative samples with effectively no ct), fast turn-around times (generally 2-3 minutes per sample), and ease of use (no technical personnel required). The continuous flow immunosensor relies on the highly specific interactions between antigen and antibody in order to produce a device which is capable of detecting small molecules (such as polychlorinated biphenyls) at parts per billion (ppb) concentrations, even in the presence of other environtal pollutants such as polyaromatic hydrocarbons (PAHs) and other chlorinated species. The antibodies are immobilized on a high surface area support medium, such as plastic beads, and are "charged" with a PCB analog which contains a highly fluorescent dye. Once in place inside the sensor, buffer is allowed to flow through the column containing the beads, effectively removing all non-specifically bound dye conjugate. Application of a PCB-containing sample into the flow stream causes some displacement of the dye-labeled PCB analog, which is then detected by a fluorometer. Environmental samples which do not contain detectable amounts of PCBs will not displace a significant quantity of dye conjugate, thus allowing the sensor to survey a large number of negative samples without loss of performance. Currently, antibodies which recognize a wide variety of PCBs are being used in our sensor with preliminary results indicating that several different Aroclors* can be detected at ppb concentrations. Additionally, antibodies against several different explosives have been tested and found to be not only sensitive to a particular antigen, but also have low levels of cross-reactivity. Future work will include the use of antibodies which are more selective for the most toxic (i.e. co-planar) PCBs, as these antibodies become available, and the development of a scheme such that quantification more than one explosive at a time is possible.

Development of Military IRIS System for the Hazard Identification and Risk Assessment/Characterization of Defense Related Pollutants

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The goal of this ongoing project is to improve the quality of the risk science that goes into risk assessments at Federal Facilities. To accomplish this, the Environmental Risk Assessment Program (ERAP) was established as a cooperative effort of DOD, DOE, and EPA to improve health and ecological risk assessments and foster consistency in risk assessments across federal agencies. Currently, there are two main functions of the program. They are the operation of the environmental risk assessment working groups and cooperative risk assessment research activities.

The Environmental Risk Assessment Council (ERAC) has been established as an interagency council to foster communication and integration of assessments and research across Federal Facilities activities. The Advisory and Coordinating Committee (ACC) has been established as an interagency committee that serves as the direct oversight and communication link between ERAC and the interagency risk assessment working groups. The risk assessment working groups have been established with distinctive charters within the Federal Facilities cleanup arena.

The Materials/Chemical Risk Assessment (MCRA) Work Group's charter activities involve developing toxicity risk assessment values for materials and chemicals of mutual concern to DOD, DOE and EPA using alternate methodologies to current procedures when appropriate; developing uncertainty analyses of toxicity values; identifying data gaps and research needs; and the dissemination of toxicity values to the risk assessment community after appropriate peer review. The Risk Assessment Methodology (RAM) Work Group's charter activities involve review and evaluation of methodologies currently used in the human and ecological risk assessment process; developing strategies for methodology changes or alternate methods where appropriate; demonstrating the use of new methods with a selected list of candidate materials and chemicals; recommending the incorporation of improved methodologies into the MCRA evaluation process when ready; and recommending alternate methods to ERAC and publishing the evaluation process and alternate methods in the open literature after appropriate peer review. The MCRA and RAM Work Groups are linked together by having several interagency members on both working groups. This facilitates transfer of methodological issues for further development from the MCRA to RAM working groups with the anticipation of finalized consensus risk assessment methods being passed back to the MCRA Work Group for implementation. The consensus science resulting from the joint MCRA and RAM working groups will not only improve Federal Facilities cleanup decisions, but risk decisions made at non-Federal Facilities as well. The cooperative research activity functions of ERAP are currently being fulfilled using four Interagency Agreements (IAGs) between the EPA and DOD, and EPA and DOE; and six Cooperative Agreements between EPA and non-governmental research organizations. The IAGs cover specific Air Force, Navy and DOE risk assessment/characterization research related to past, present and projected future issues pertaining to their respective cleanup activities. The Cooperative Agreements were based upon a competitive selection process that resulted in six agreements that will best fulfill current and future data/methodological needs of ERAP for Federal Facilities cleanup.

Anaerobic Biotransformation of Chlorinated Ethenes

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Tetrachloroethene (PCE) and related less-chlorinated ethenes such as trichloroethene (TCE), dichloroethene (DCE) isomers, and vinyl chloride (VC), have been used widely since the 1940's as degreasing and dry cleaning solvents. This widespread use, in addition to improper handling and storage, has caused groundwater contamination. Treatment processes for the removal of PCE and TCE from groundwater include air stripping, carbon adsorption, and ozone or ultraviolet/ozone treatment. PCE, TCE, DCE and VC, have been observed to be reductively dehalogenated by anaerobic microorganisms. Aerobic bioremediation is only applicable to the lesser chlorinated ethenes.

The possibility of anaerobic bioremediation of PCE has sparked the interest of many researchers. The cost of creating an aerobic environment in the subsurface is often prohibitive and impractical. Development of an *in situ* anaerobic biological treatment for technology for PCE contamination would offer a cost-effective destructive remediation method. Understanding the microbiology of reductive dechlorination will enable researchers to utilize and control the processes that remove chlorinated ethenes from the environment.

AL/EQW and Cornell University are presently investigating the anaerobic biodegradation of PCE using a methanol (MeOIT)/PCE enrichment culture. The culture dechlorinates and completely detoxifies high concentrations of PCE to ethene (ETH) with efficient use of MeOH as the electron donor for reductive dechlorination. When lower, non-inhibitory concentrations of PCE concentrations of PCE are present, methanogenic activity rises and consumes an increasing fraction of MeOH equivalents, necessitating ever-greater additions of MeOH to allow dechlorination. MeOH is not the director donor for PCE dechlorination, but rather the released H_2. MeOH appears merely to serve as an H_2 precursor.

Butyrate has been identified as an alternate electron donor which circumvents the problem of methanogenic competition. Microbiological studies towards a better understanding of the nature and the nutritional requirements of the dechlorinating organisms have been initiated. The addition of a simple vitamin solution to the culture has been found to both sustain and enhance the dechlorination of PCE to ETH. The kinetics of chlorinated ETH utilization are currently being studied, with emphasis on VC dechlorination to ETH. Issues of acclination and induction are also being studied. The selected substrate, butyrate, will be used in a continuous-flow reactor study with the H_2/PCE enrichment culture. Insight form these studies will be employed by the AF and EPA in designing an *in situ* anaerobic to be implemented in the summer of 1995.

A Subsurface Gas Flowmeter

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A new instrument is being developed which uses a thermal perturbation technique to directly measure the magnitude and direction of the full three dimensional gas flow velocity vector in unsaturated, permeable materials. The technology should be very useful for monitoring the dynamics of vapor injection/extraction systems, both passive and active. The technology is similar to the In Situ Permeable Flow Sensor which measures groundwater flow velocity in water saturated sediments and is currently being commercialized. Two versions of the gas flowmeter are envisioned, both of which must be buried in the subsurface, in intimate contact with the formation. The first will measure the full 3 dimensional air flow velocity in the subsurface while the second version, which will be considerably stronger and hence easier to install, will only measure the vertical component of the flow. It is envisioned that the vertical component version will be particularly useful for shallow (< 5 meters) studies of the interaction between atmospheric and subsurface air across the ground surface.

A short, proof-of-concept test of the gas flowmeter was conducted at the Hanford Site, WA in July of 1994 with funding from the DOE Office of Technology Development, EM50. A probe was buried 5 m in the ground in between two wells each of which had a 1 meter screen at a depth of 5 meters. The probe was located 3 m from one of the holes and 10 m from the other. Air was first extracted from the hole that was 3 m from the probe, at a rate of 15 l/s. A gas flow velocity of about 0.09 cm/s, directed toward the gas extraction well, was observed by the flow sensor. Then the vacuum extraction system was moved to the hole 10 meters from the flow sensor and the direction of the flow velocity observed by the flow sensor began to change toward that well. Before the observed flow velocity could equilibrate at the new orientation, the experiment ended prematurely due to generator failure. The experiment demonstrated that the technology is clearly sensitive to gas flow velocity.

SERDP funding is currently being used to investigate the accuracy, sensitivity and applicability of the instrument. The technology will be tested using numerical simulations, laboratory tank experiments and field trials. A tank has been designed and is currently being fabricated. It will be approximately 3 meters high and 1.2 meters in diameter and will be buried in the ground with the top of the tank located at approximately the ground surface. It will be filled with sand and be fitted with air inlet pipes through which air will be injected at the bottom of the tank, an air outlet port at the top of the tank and numerous pressure and temperature monitoring points. Probes will be deployed near the center of the tank and air flow with a known velocity induced past them. It will be possible to deploy the probes vertically in the tank to measure the flow of air parallel to the long axis of the tool or to deploy them horizontally to test the ability of the technology to measure flow perpendicular to the long axis of the probe.

The National Center for Integrated Bioremediation Research and Development

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Wurtsmith Air Force Base (WAFB) was decommissioned in June of 1993. Shortly thereafter, the United States Environmental Protection Agency (U.S. EPA), the Strategic Environmental Research and Development Program (SERDP) of the Department of Defense (DoD), the University of Michigan and the Michigan Department of Natural Resources joined resources to develop the National Center for Integrated. Bioremediation Research and Development (NCIBRD). NCIBRD is a DoD National Environmental Technology Demonstration Program Location for the development and evaluation of site characterization and remediation technologies. The mission of NCIBRD is to provide a well defined and controlled research and development platform for in-situ environmental cleanup technologies emphasizing bioremediation techniques applied to subsurface contamination problems. The mission focuses on technologies which have the potential to remediate unsaturated zone and saturated zone contamination in subsurface systems without extensive excavation, site-disruption, or displacement of contaminated environmental media (i.e. soil, sediments and water). The long range goal of both the National Environmental Technology Demonstration Program and NCIBRD is to foster development of means for accelerating the reclamation of contaminated federal facilities, and thus their return to productive civilian use.

WAFB is located in losco County in northeast Michigan (MI) in the coastal zone of Lake Huron north of Oscoda, Michigan. Oscoda is accessible by rail, highway and commercial air routes north of Saginaw-Bay City, MI. It is under the authority of the Oscoda-Wurtsmith Airport Authority and the Wurtsmith Area Economic Adjustment Commission. The U.S. Air force Base Conversion Authority (BCA) is charged with remediation of sites of contamination to enable the transition of site facilities to civilian use. At present, five private or public concerns have leased sites on the base for operations involving an aircraft maintenance facility, a plastics manufacturer, educational institutions and recreational resources. There are approximately fifty ground-water sites which contain mainly chlorinated solvents and fuels as organic contaminants. NCIBRD is involved in the demonstration of intrinsic bioremediation at a fire-training area and in the evaluation of multiple sites for other in-situ bioremediation R&D efforts. NCIBRD provides the infrastructure on-site to support the development and evaluation of site characterization. Inquiries from prospective collaborators are encourage.

In-situ "INSIDE-OUT" Nuclear Magnetic Resonance Sensor for Contaminant Identification

Gary F. Mastny & Mark North

A remote, (inside-out) NMR sensor and spectrometer will be developed for use in the rapid detection, identification and mapping of contaminants at hazardous wastes sites. This system will utilize accepted site screening methology, i.e., test wells, to generate a rapid, vertical subsurface profile. This work is a joint effort of NRaD and their industrial partner, Quantum Magnetics (QM), Inc. QM will furnish a state- of-the-art NMR spectrometer and consulting services. The development of functional design and specifications for the sensor head (physical and electronics suite) will be accomplished jointly. The prototype sensor head will be fabricated by QM, and NRaD will integrate the sensor head and spectrometer, characterize its performance in the laboratory and conduct field tests.

Enhancing Bioremediation Processes in Cold Regions

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Biotreating contaminated soils in cold regions is constrained by low temperatures, logistics, and lack of suitable alternatives. From earlier projects, we know that: i.) bioavailable nutrients and carbon can limit microbial activity in contaminated soils, ii.) enhanced microbial activity resulting from satisfying the demand for carbon and nutrients can increase soil temperatures, iii.) although information about microbial kinetics at low temperatures is sparse, evidence suggests that Q10 values for microbial activities in soils from cold regions are greater than usual, and iv.) soil freeze-thaw cycles often result in bursts of microbial activity. Our objective is to develop the capability to exploit these phenomena as part of predictable and cost-effective treatment options which are applicable to cold regions or winter use.

Our approach is to merge research on two thrusts: i.) to quantify the effects of low temperatures and freeze-thaw processes on soil microbial activity and contaminant biotransformations, and ii.) to enhance microbial activity in soils by improving carbon and nutrient bioavailability by rhizosphere enhancement, an extremely low cost strategy. We have developed a respirometer system to study freeze-thaw and soil moisture/low temperature effects on soil respiration. Using contaminated soils, we have measured Q10 values that differed significantly from 2, the value usually assumed as correct. The difference between the measured and expected Q10 values varied with soil moisture and soil carbon. These results are significant in predicting temperature impacts on biotreatment times. We have also observed that the impact of organic compounds on plant and root growth is both plant-species and contaminant specific. Roots of four cold-tolerant plants grew through soil contaminated with approximately 30,000 mg/kg PAHs, and exhibited increased proliferation and root-hair growth in non-contaminated soils. In a related study, root growth of alpine bluegrass was stimulated by a model contaminant containing 2000 mg/kg of five organic compounds. These results are significant because the mass transfer of contaminants often limits in-situ treatment strategies, and root distribution would partially address soil mass-transfer limitations. For plant species we have studied, organic-compound degrading micro-organisms, expressed as a percentage of the total microbial population, were selectively enriched in the rhizosphere of contaminated soils. Results from these studies suggest that bioremediation may be enhanced in rhizosphere soils, and there are opportunities for managing field systems to promote the synergistic effects of freeze-thaw and rhizosphere phenomena to favor soil cleanup. In addition to terrestrial systems, we are extending these techniques to sediment treatment using aquatic plants.

Demonstration of Enhanced Source Removal for Aquifer Restoration

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Subsurface contamination is the factor limiting site remediation at most military facilities. It is estimated that more than 90% of the contaminant mass is associated with the source area and only 10% or less associated with the dissolved plume. Currently, the treatment method of choice is some form of "pump-and-treat" which has been shown to be effective in limiting the spread of contamination but has been ineffective in removing the source of contamination.

The two primary objectives of this program are to: (1) evaluate (in side by side comparisons) innovative technologies to reduce the contaminate mass in the source area; (2) develop design guidance manuals which will permit full scale design of treatment systems with realistic expectations for the performance of these systems. Ideally, the contaminants of interest can be reduced in mass to a level where either the site can be abandoned without additional proactive remediation or bioremediation or some other more traditional remediation can effectively complete the remedial activities.

The approach is to construct hydraulically isolated cells in an existing contaminated site. Hill AFB was the first site selected to evaluate the technologies. The current program status is: (1) A cosolvent solubilization cell is installed, characterized and instrumented. Remediation is scheduled for the second week of April 95. (2) The work plan for the remaining eight cells is being reviewed by state and federal regulators and scheduled for installation in the summer of 95.

Technologies to be evaluated include: cosolvent mobilization, surfactant solubilization, surfactant mobilization, emulsion transport, macromolecule transport, sparging, venting and steam.

Hot Gas Technology to Decontaminate Excavated Underground Piping

Louis Kanaras

The manufacture, handling, and loading of explosives at Army industrial facilities have resulted in the contamination of process equipment (piping, pumps, motors, powder boxes, etc.) and sewer systems. Because of this residual contamination, process equipment, piping, and sewer lines cannot be reused or disposed as scrap without some sort of remedial treatment.

Over the years, the U.S. Army Environmental Center (USAEC, formerly USATHAMA) has investigated technologies that can be used to effectively treat explosives contaminated materials. Using process equipment supplied by the Government, pilot studies conducted at Hawthorne Army Ammunition Plant (HWAAP) have shown that decontamination of explosives contaminated structural components is possible using a heated gas to thermally decompose or volatilize explosives with subsequent destruction of the volatilized explosives taking place in the afterburner.

Based on engineering data gathered during the Hawthorne pilot studies, Roy F. Weston, Inc. under contract (with SERDP Funding) to USAEC, was tasked to downsize the hot gas decontamination system equipment to a size which is transportable, and easily procured through commercial sources. This equipment is currently being designed and fabricated and is being readied for shipment to the Alabama Army Ammunition Plant (ALAAP) for assembly and equipment startup/shakedown activities. Subsequent to startup/shakedown activities, Demonstration/Validation (DEMVAL) testing shall be conducted with explosives contaminated piping and oversized debris. Fifteen (15) test runs shall be conducted during the DEMVAL test in order to identify optimum operating conditions and to verify the effectiveness of the hot gas system to remediate explosives contaminated piping and debris to levels which would allow this material to be disposed of as scrap while maintaining at least 99.99% destruction and removal efficiency (DRE) of contaminants out of the afterburner. This DEMVAL testing is currently scheduled to commence in the July 1995 time-frame and is being funded under Defense Environmental Restoration Account (DERA) funding.

At the conclusion of testing activities with the hot gas system at ALAAP, Weston shall develop a system specification to support future procurement activities; an operation and maintenance manual for the safe and efficient operation of the hot gas system equipment; and cost analyses to support installation restoration and base closure activities where explosives contaminated piping, process equipment, and debris pose disposal nightmares.

Abiotic Degradation of Chlorinated Solvents

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The focus of this research is to examine abiotic proceses for degrading the chlorinated solvents TCE and PCE which may be used in subsurface treatment systems for the remediation of contaminated groundwater. Biochemical processes which function external to living organisms are also considered.

Preliminary efforts primarily dealt with gaining a better understanding of heterogeneous (i.e., surface-mediated) reactions. Batch and flow-through system experiments were conducted using the reduction of nitrobenzene with metallic iron as a model system. A computer model was developed which incorporates flow-through system, reactive and non-reactive sorption sites, and mass transfer limitations.

The reduction of PCE and TCE with metallic iron is currently being examined. The primary products have been determined to be acetylene, ethene and ethane. Efforts will be made to determine the identity of minor unknowns. Sorption of PCE and TCE onto metallic iron has been determined. Results indicate that apparent sorption equilibrium is reached after 24 h. Both show strongly nolinear sorption isotherms, either Langmuir or Freundlich for PCE and Freundlich for TCE. The reaction is complex and is not simple pseudo-first order, but appears to reduce to first order once sorption is taken into account. Experiments will be conducted to determine the connection between the batch and column systems, as well as the influence of dissolved solids. The reduction of chlorinated solvents using metallic iron is a very promising remedial technology.

Biochemical approaches being examined are: 1) dehalogenase derived form an anaerobic microbial consortium (from J. Gossett, Cornell U.); and 2) reduction via vitamin B_{12} cataysis. Purification of the dehalogenase is nearly accomplished. The enzyme reduces PCE and TCE to ethene. Efforts to incorporate the enzyme in a heterogeneous reaction system will be attempted. The vitamin B_{12} work will begin shortly.

Real Time Neural Network Raman Signal Enhancement

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A Raman spectrometer is being developed that utilizes Neural Network (NN) signal processing to extract the chemical signatures of VOCs from spectra exhibiting extremely high noise levels, resulting in enhanced sensitivity of the Raman technique. The Raman system is used to both identify and quantify DOE/DOD target organic and inorganic contaminants in both solid samples (Hanford UST) and ground-water, with a secondary application being the location and identification of subsurface NAPLs. The system utilizes a NN package that is being developed by Physical Optics Corporation (POC) for real-time signal extraction from high background noise in conjunction with a remote Raman spectrometer being developed at LLNL. The POC NN is unique in that it is based on a hardware rather than a software approach. The advantages of the hardware approach are the large number of data points that can be simultaneously analyzed and greatly reduced processing time. The NN is trained to recognize chemical contaminants at concentration levels potentially ranging from EPA limits in soils and water to neat solids and liquids.

The NN has been trained to recognize the Raman spectral signatures of the organochlorides CCl4, CHCl3, DCM, TCE, and TCA. The training of the NN is accomplished using single component organochloride spectra with signal to noise ratios in the range of 5:1 to 35:1. Once the training is complete, the NN is asked to identify approximately 75 low S/N (<1:1) spectra of individual organochlorides and four and five component organochloride mixtures. The NN gives correct identifications with 93+% accuracy, and gives 100% rejection of spectra consisting only of noise. Only 30 milliseconds are required to perform a complete deconvolution of 1024 spectral data points, including composition identification and notification of the operator as to the results.

The NN is also able to positively identify 2500 ppm (V/V) CCl4 in methanol with 100% confidence and 250 ppm (V/V) with 65% confidence. This represents an enhancement of the detection limits of CCl4 by Raman spectroscopy by 2 orders of magnitude. These results indicate the power of the NN system to both extract real signal which appeared nonexistent from extremely high noise levels and readily provide component analysis of highly complex spectral information. We are continuing to develop the potential of the NN into a viable system that has a wide application in analytical chemistry.

Groundwater Remediation Field Laboratory

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Cleanup of soil and groundwater contamination due to chlorinated solvents is expected to consume a disproportionate share of the total estimated $35 billion DoD cleanup budget. This is largely due to the paucity of technologies that are truly capable of detecting, measuring, or cleaning up the dense nonaqueous phase liquids (DNAPLs) that are associated with subsurface solvent contamination. The Air Force Armstrong Laboratory, Environics Directorate, as part of the SERDP DoD/National Environmental Technology Demonstration Program (D/NETDP), has located a test site where the conditions are ideal for establishing a field laboratory to concentrate predominately on DNAPL technology development, demonstration, and transfer. The Groundwater Remediation Field Laboratory, (GRFL), is now located at Dover AFB, DE. It is a member test location of the SERDP D/NETDP network and as such will benefit from the management structure, data standards, and reporting framework that is characteristic of the D/NETDP. Existing, well characterized, fuel and solvent contamination plumes are available for demonstrations, but the defining feature of the GRFL is the ability to do strictly managed, contained release experiments at a well characterized, uncontaminated portion of the test location.

Advanced Fuel Hydrocarbon Remediation Technologies National Test Location

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The Advanced Fuel Hydrocarbon Remediation Technologies National Test Location is at the Naval Construction Battalion Center (CBC) Port Hueneme, California. A 3.8-acre ex situ soil remediation facility is operational on the Base where gasoline-and diesel-contaminated soil has been stockpiled for controlled tests. The facility is monitored to detect any contaminant migration from the site. In addition to the ex situ site, several isolated sites have been identified for in situ site characterization and remedial demonstrations. Technologies for contaminated soil, ground water, and harbors, canals and wetlands can be demonstrated at this site. The geology, within 30 feet of the surface, consists of unconsolidated sands, silts, and clays with minor amounts of gravel and fill material. A semi-perched aquifer with isolated contaminated plumes is the uppermost ground water unit present beneath CBC. A three dimensional monitoring network with long-term data retrieval is available for demonstration technology comparisons.

The Advanced Fuel Hydrocarbon Remediation Technologies National Test Location is a member of the SERDP D/NETDP network and as such will benefit from the management structure, data standards and reporting framework that is characteristic of the D/NETDP.

Kinetic Mechanisms of Supercritical Water Oxidation

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Supercritical water oxidation (SWCO) is an emerging technology for the treatment of a wide variety of aqueous organic wastes. The technology is in the early stages of commercialization. The SERDP project "Kinetic Mechanisms of Supercritical Water Oxidation" is designed to develop predictive models for the oxidation of key organic species. The compounds that are to be studied have been identified as being particularly robust under these processing conditions and as a result are likely to be process limiting in large scale systems. The project uses two high pressure reactors equipped with optical windows that allow for spectroscopic detection of the reacting species. These detailed measurements serve as an experimental basis for developing elementary reaction step models that can be used to interpret the overall oxidation process. These models can then be reduced into a simplified form to be used as a design and operational tool for large-scale waste-processing systems.

We have had success using Raman spectroscopy as a quantitative *in situ* diagnostic. Methanol oxidation has been monitored over a temperature range from 440 °C to 500 °C at 250 bar using spectroscopic monitoring. In addition to observing the loss-of-fuel rate, we have been able to quantify the formation of formaldehyde as a key intermediate. An elementary reaction model has been developed in collaboration with Prof. J. Tester's group at MIT that can describe not only fuel consumption, but the production and subsequent oxidation of formaldehyde as well. We have combined these methanol results with our understanding of methane oxidation to produce a generalized C_1 oxidation mechanism. In developing this model we have extended the applicability of Chemkin Real Gas, a high pressure version of Chemkin -II, to cover non-ideal mixtures in supercritical water.

Recent experimental measurements have focused on 1- and 2-propanol with 2-propanol showing a well defined partial oxidation to acetone in the 400° C - 450° C range that is analogous to the oxidation of methanol to form formaldehyde.

Shipboard Non-Oily Wastewater Treatment System

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Shipboard graywater is the product of hotel and commissary-type activities aboard U.S. Navy ships. Common sources of graywater are showers, sinks, and galley and scullery equipment. During the 1970's, environmental legislation required the Navy to outfit its ships with collection, holding, and transfer systems which were designed to: (1) collect and hold sewage for 12 hours while in transit through a 3-mile contiguous zone, and (2) collect sewage and graywater, and transfer these wastes ashore while a ship is pierside. No graywater holding capacity was required for U.S. Navy ships with the exception of operations within the Great Lakes. However, in light of increased public environmental awareness, and the anticipation of tightened global wastewater discharge regulations, the Chief of Naval Operations and Naval Sea Systems Command have identified the need to develop technologies which are appropriate for the control and treatment of shipboard graywater as one of their environmental priorities.

In response, engineers and scientists at the Naval Surface Warfare Center, Carderock Division at Annapolis, Maryland are developing a membrane-based graywater treatment system. A laboratory prototype 2000 gallon per day treatment system has performed successfully in the laboratory using Navy-generated land-based graywater mixtures. The first stage of the system uses polymeric large-bore membranes to trap coarse and fine solids and to remove up to 90 percent of the influent biochemical oxygen demand (BOD). A second-stage nanofilter enables the system to remove dissolved organics and further reduce the effluent concentrations of BOD and suspended solids. Commercial manufacturers, industrial membrane users, membrane experts, and academic researchers are assisting in the development of this graywater treatment system.

Leak Location in Underground Pipelines

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Underground pipelines are used by industries worldwide to transfer large quantities of liquid products. Presently, only two methods are used to locate leaks in these pipelines; both are time consuming, costly, and disruptive to service operations. In addition, the performance and reliability of these methods are highly suspect. The application of passive acoustic principles to leak detection/location offers the potential for a more accurate and cost effective solution to this problem. Pipelines can be tested in minutes rather than days. Leaks can be located in pipelines without having to use invasive techniques which are especially costly in low-level radioactive waste lines. Remediation costs will diminish significantly as releases are detected and located earlier and more accurately. In addition, more accurate on-line monitoring capabilities will enable better control over product transfer systems, and will assist in preventing the release of millions of gallons of contaminants into the environment.

The overall objective of this applied research project is to develop, design, fabricate, and demonstrate a passive acoustic leak detection/location system that can be used on: (1) existing and newly installed pipeline systems, (2) pipeline systems that cannot be breached, and (3) pipeline systems of various sizes, compositions, and configurations. Such a system would not only assist the regulated community in complying with existing state and federal regulations but would also reduce the spread of contamination into the Nation's potable groundwater resources through early and more accurate leak detection/location.

A three-phased development and demonstration program will be conducted over a three-year period. Phase 1 will involve modification of EPA's UST and Pipeline Test Facility by adding three experimental pipeline systems that are representative of (1) retail service stations, (2) double-walled steel pipeline systems that are typically used at DOE installations to transfer low-level radioactive wastes, and (3) 12-inch diameter high pressure pipeline systems that are used by DOD to transfer fuel and water. Detailed experiments will be conducted on these systems to determine and improve the accuracy and performance of acoustic technology for locating leaks of differing sizes over variable distances. Phase 2 will utilize the information gained in Phase 1 to design and fabricate a portable acoustic leak detection/location system. Shakedown testing of the portable system will be accomplished by conducting controlled condition tests at the EPA test facility and field evaluation studies. In addition, the development of an on-line automatic acoustic system that can be attached to existing or new pipeline configurations will be investigated. Phase 3 will result in the refinement of the portable acoustic system hardware and software and in the development of the on-line system if deemed appropriate.

Laser Ablation/Ionization Characterization of Solids

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Laser ablation is an important technique in an increasing number of fields including chemistry, physics, materials science, microelectronics, biology, and medicine. The utility of laser ablation is derived from the diversity of materials that are amenable to the technique. Nearly any solid material can be vaporized t form concentrated pulsed plumes that can be analyzed by mass spectrometry, laser-induced fluorescence, and other techniques. Laser ablation combined with mass spectrometry (LAMS) is being developed as a diagnostic for atomic and molecular species in mixed hazardous wastes. Using this approach, analysis of complex, multicomponent mixtures can be performed rapidly using very little sample. Reduced sample size is highly desirable for the analysis of many hazardous wastes because it minimizes the secondary waste generated from the analytical procedures. In specific, the LAMS technique is being developed to analyze mixed wastes (radionuclides + chemical mixtures) extracted from the underground storage tanks at the Hanford nuclear reservation.

Knowledge of the ablation mechanisms is needed to determine the correlation between the ablation products and the original sample composition. Under certain conditions (e.g., high laser fluence) the final products may be heavily influenced by the chemistry occurring in the laser induced ablation plasma near the surface. It is critically important to understand the chemistry of the ablation process if LAMS is to be used as a diagnostic tool for determining the chemical speciation and structure of the original material. The present work examines conditions that permit laser ablation to be used as a chemical analytic probe. Sodium nitrate is a major component of some Hanford-site waste tanks and therefore we have studied the laser ablation of sodium nitrate in detail to understand its ablation mechanisms. We have then dosed known waste compounds onto sodium nitrate to simulate mixed waste conditions. We present detailed results of laser ablation of sodium nitrate and in order to evaluate the utility of LAMS for analyzing mixtures of various complexity we present preliminary analysis of wast compounds dosed onto the nitrate matrix. Particular attention is placed on determining the optimal laser wavelenghts and pulse energies for laser ablation mass analysis.

Atmospheric Dispersion Model Development for Open Burn/Open Detonation Emissions

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The disposal of unwanted munitions, rocket propellants, and manufacturing wastes is required at Department of Defense (DoD) installations. The most common disposal method is open burning (OB) or Open detonation (OD) of the material, which results in potential pollutant releases to the atmosphere. This paper describes the first year efforts toward the development of an air pollution dispersion model for predicting OB/OD emissions. The model has three unique features: (1) the capability to deal with buoyant plume rise from quasi-continuous burning or cloud rise from instantaneous detonations, (2) the prediction of dispersion based on modern scaling concepts for the convective and stable boundary layers, and (3) the use of onsite profiles of wind, temperature, and turbulence from a mobile meteorological platform. The platform is necessary due to the remote location of many of the DoD installations and the meteorological data requirement for the dispersion predictions. The model framework includes analytical formulations -- Gaussian plume and probability density function approaches -- as well as the potential for numerical wind field calculations, when necessary, in areas of complex terrain. This work is being sponsored by the DoD/DOE Strategic Environmental Research Development Program.

Characterizing Emissions Produced By Open Burning / Open Detonation

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For more than 40 years, open burning/open detonation (OB/OD) thermal treatments have been the disposal methods of choice for destroying unwanted energetic materials. Although these methods have continuously proven to be the fastest, safest, least expensive, and best understood, they are being challenged by Federal and state environmental regulators and a variety of civic action groups. In most instances, the problem is one of perception. The dense clouds characteristic of many OB/OD sites appear threatening and, in the absence of solid scientific information otherwise, emotion has judged that emissions are dangerous to human health and the environment. The U.S. Army Armament, Munitions and Chemical Command (AMCCOM), as the single manager for conventional munitions, initiated a large-scale field experiment in 1985 to determine the feasibility of obtaining data on OB/OD-generated emissions. From this beginning, a testing system has evolved which characterizes OB/OD emissions to the satisfaction of the USEPA and a growing number of state regulators. Known as the BangBox testing system, it can test a wide variety of munitions with net explosive weights (NEW) less than 227g, and propellants weighing less than 2.27kg. However, technological enhancements to this testing system are necessary before it can play a dominant role in supporting reduction of the demilitarization inventory and providing information helpful for determining allocation of approved funding for alternate technology research and development. New facilities capable of increasing the NEW to the point where most explosive munitions can be tested and soil can be integrated into the test procedure needed. The means of testing and characterizing chlorine-containing energetic materials such as ammonium perchlorate-based propellants, need to be developed. The technique of grouping munitions by emissions families, thereby obviating the need for testing all munitions, needs to be perfected. All of these progressions are currently being pursued under SERDP sponsorship. This presentation briefly describes evolution of the present BangBox testing system, defines the system and on-going testing projects, summarizes recent data and permitting successes, and outlines future development plans.

Steady-State and Nonsteady-State NOx Emission Control

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Previous study has demonstrated that magnesium oxide (MgO) coated on vermiculite removes oxides of nitrogen (NOx) from relatively low-temperature combustion exhaust streams. However, in contrast with conventional NOx control technologies, MgO on vermiculite exhibits nearly constant reactivity toward NOx over a fairly wide range of temperatures and space velocities. Results from a field test on jet engine test cells (JETCs) at Tyndall and Wright-Patterson AFBs were sufficiently encouraging that a large-scale operational test was proposed for a hush house at McClellan AFB. The broadly favorable performance characteristics and ready regenerability of MgO--vermiculite sorbents also inspired a second proposal, to apply the same sorbents to exhausts from such relatively constant sources of NOx as diesel generators, heavy vehicles and diesel-powered construction equipment, and space heaters. Recent upsurges in regulatory pressure at California bases has directed emphasis on aircraft ground equipment (AGE). Both subprojects were funded by SERDP under the title heading.

In the hush house activity, we are constructing the ducting and treatment system for the JETC. The design extends the exhaust at the back of the JETC toward the front of the hangar. The duct splits into two sweeping curves that drop to the ground and swing back to the sides of the JETC at the intakes providing flow to the augmentor. Six separate treatment ducts remove 50,000 cfm each and draw it through obliquely oriented panels filled with MgO--vermiculite, and the return duct feeds untreated exhaust back to the augmenter, which accounts for about 40 percent of the net exhaust airflow. When a TF-33 engine (the largest in McClellan's inventory) operates at full afterburner, this device will treat about 2/3rds of the exhaust (exact flows will be measured before and after takeoff to the ducts, and in each of the ducts). NOx removal will be scaled to total volume flow per gallon of fuel consumed (and corrected for untreated air) to determine unit cost of control, which is the critical question to be answered by these two subprograms.

The steady-state subprogram is actively designing and assembling a prototype tailpipe emission control device to field test at McClellan or March AFB CA (to address an urgent requirement to control NOx emissions from AGE sources). A second device, to be installed on and tested as a control for several other fixed or slightly mobile combustion sources, is also being fabricated for installation and intermediate-term (4- to 6-month) testing on heavy equipment and generators. The AGE equipment standards have been set unreasonably low, so the ability of the device to attain the regulatory levels is as critical a question as the unit cost of control.

Advanced Mass Spectrometry for Clean Air Compliance

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The purpose of our research is to develop a novel, ultra-high sensitivity mass spectrometer for measuring trace hazardous, toxic, or other regulated gases in the atmosphere. The instrument uses optimized electron impact ionization in addition to atmospheric pressure chemical ionization to attain sensitivities in the sub-part-per-billion range. In this talk, we will discuss progress in developing the prototype instrument, several recent field tests, and chemical ionization reaction schemes for detecting chlorine nitrate and SO_3. Plans for future ground-based and aircraft-based field campaigns in support of Air Force and NASA compliance goals will be discussed. Finally, the mass spectrometer will be placed into the context of other Clean Air Act compliance research/instrument development at the Geophysics Directorate.

Lead-Based Paint Hazard Mitigation

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Recent tests indicate that the leaching rate of lead from glass can be reduced from 30 ppm to less than 1 ppm when the glass composition contains 14% iron oxide. Lead oxide was spiked into the glass composition at a concentration of 10%. Previous tests have demonstrated that lead-based paint can be removed using molten glass spraying. The combination of these two technologies has the potential for solving a significant hazardous waste problem during the demolition of buildings which have been coated with lead-based paint. A double benefit is achieved by reducing both disposal costs and fugitive dust emissions.

The lead-based paint hazard mitigation project involves the preparation of vitrified materials to encapsulate the lead oxide and determine through characterization techniques how the hazardous waste is incorporated within the glass structure and immobilized. The mechanisms of vitrification and ion leaching will be modeled to optimize hazardous waste immobilization. This model will be used to engineer a new stable designer glass composition for vitrification. Existing and recently developed laboratory tests will be used to predict the leaching and long term durability of the vitrified waste form.

Demonstrations of emerging technology for lead-based paint removal are being conducted at DoD installations. Environmentally compatible chemical strippers and sponge blasting were evaluated in the laboratory. Full scale demonstrations are being conducted to evaluate the cost for environmental compliance for lead-based paint abatement.

Encapsulation of Hazardous Ions in Smectite Clays

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Clay minerals, and other intercalation compounds such as zeolites, have been proposed for the storage of hazardous ions. Smectite clays consist of sheets of aluminosilicates which are separated by an interlayer that contains both inorganic cations, such as calcium and potassium, and water molecules. These cations can be easily replaced by other hazardous cations through aqueous ion-exchange processes. However, the long-term storage of the clay after addition of the hazardous material is problematic. Clays are naturally hydrophilic materials. As a result, the ions enclosed within the clay are still susceptible to leaching by water. We have investigated the utility of modifying the surface of natural clays to create a hydrophobic clay after a hazardous ion has been introduced into the inorganic matrix. Such materials should resist the removal of ions from the clay upon exposure to polar liquids. The method for creating hydrophobic clays is based on self-assembled organic monolayers. The resulting materials have been characterized by several analytical methods, including X-ray absorption spectroscopy (XAS), X-ray photoelectron spectroscopy (XPS), gas absorption (BET), and anomalous small angle X-ray scattering (ASAXS). The ability of these hydrophobic clays to resist leaching of the stored ion is currently being evaluated.

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Development of Hydrothermal Reduction of Energetic Wastes

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Current incineration and open burning/open detonation methods generate air and solid pollution, require permits and site remediation, and are at risk for increased regulation and possible shutdown. The wet air oxidation and supercritical water oxidation operating regions have been explored in other efforts. Exploration of Hydrothermal Reduction (HTR) provides additional, potentially more economical, treatment options and reduces the overall risk in the development of alternatives to disposal by OB/OD.

Destruction of energetic materials, which are characteristically oxidant rich, in water at temperatures just below the critical point and under reducing conditions (hydrothermal reduction) has received little attention. In a previous research effort, decomposition of individual energetic materials into smaller, nonenergetic molecules under conditions of hydrothermal reduction was verified in bench scale experiments, and it was discovered that certain salts act as a catalyst or promoter. For example, RDX is transformed primarily to formaldehyde, nitrate, and ammonium. For energetics containing a strong oxidizer, such as ammonium perchlorate, a reducing agent is added in order to consume the oxidizer.

The goal of this project is to develop hydrothermal reduction (HTR) as an alternative to chemical hydrolysis for use in systems designed for the safe, nonpolluting disposal of waste solid rocket propellant from manufacture, refurbishment, and demilitarization of large rockets and for disposal of selected Army, Navy, and Air Force conventional munitions. Final treatment of hydrolyzed energetics from the hydrothermal reduction treatment process could then be treated by biodegradation, supercritical water oxidation, or advanced oxidation processes. Applications for hydrothermal reduction include treatment of Class 1.1 solid rocket propellant, Explosive D (ammonium picrate), concentrated ammonium perchlorate waste streams and possible recovery of unoxidized aluminum from the ammonium perchlorate contaminated aluminum/binder residue generated in the Class 1.3 propellant ammonium perchlorate recovery process.

Metal Perovskite Catalysts for NOx Reduction

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To comply with and anticipate federal, state, and municipal regulations limiting emissions of nitrogen oxides (NO_x) from combustion processes, the U.S. Air Force Armstrong Laboratory Environics Directorate (AL/EQ) is researching a broad range of technologies for NOx reduction.

Of particular interest are technologies which offer NO_x reduction or oxidation in high-temperature, high-flow environments. AL/EQ has teamed with the U.S. Army Construction Engineering Research Laboratory (CERL) to investigate a catalyst for high-temperature NOx reduction. CERL conducts research in many areas of materials engineering, including ceramics and corrosion control. Previous investigations have shown that lanthanum cobaltate ($LaCoO_3$) can reduce 90 percent of NO_x at temperatures above 660°C. The $LaCoO_3$ is reduced is the process, resulting in a loss of catalytic activity. Replacing some of the La ions with Sr ions yields strontium-lanthanum cobaltate ($Sr_xLa_{1-x}CoO_3$), which may be a more stable catalyst and provide more efficient NO_x conversion. This research effort will determine if the oxygen-deficient structure of $Sr_xLa_{1-x}CoO_3$ can be stabilized for long-term use as a high-temperature (1200-1500°C) NOx-reducing catalyst without significant catalyst material losses.

Catalyst material is being currently being prepared. Several compositions which display good stability and catalytic activity for NOx will be tested. Chemical analysis, phase analysis, and impurity analysis will be performed. The thermodynamics and kinetics of catalytic active phases of $Sr_xLa_{1-x}CoO_3$ will be studied in simulated combustion exhaust gas streams, with the following possible composition: 10 percent CO_2, 5 percent N_2, 2 percent H_2O, 0.5% NO, and a balance of N_2. A high-temperature furnace will be used to conduct tests at 1200-1500°C. Thermogravimetric analysis (TGA), differential thermal analysis (DTA), differential scanning calorimetry (DSC), and x-ray diffraction will be utilized to determine the catalyst stability. If a suitable catalyst structure is identified, NOx reduction will be characterized using a gas analyzer, and by-products will be characterized using gas chromatography and mass spectrometry. Finally, the catalyst will be demonstrated in long-term high-temperature tests on a yttria-stabilized zirconia (YSZ) or other ionically-conducting substrate.

Potential applications targeted include turbine and combustor coating to remove NOx during and after combustion in Air Force jet engines and Army helicopter and tank turbines. The catalyst may also find application in continuous-use boilers and incinerators.

Reduction of NOX Emissions from Marine Power Plants

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Naval commands, operating within the California littoral have been directed by the Navy to make a good-faith attempt to comply with anticipated state and federal limits on NO_x emissions. A fleet inventory of about 700 gas-turbines plus about 1400 diesel engines, often operating continually within the littoral, constitute a class of engines, and Navy ships presently in severe violation of the proposed NOx limits.

One low-risk, low-cost, state-of-the-art development achieves low-emission power plants by injecting water, simultaneously with the fuel, into the gas-turbine combustor or diesel engine cylinder. This water injection lowers the temperature of the combustion process, and reduces NOx emissions below anticipated CARB-mandates. Water injection reduces NO_x in diesel engines, but exhaust gas recirculation also appears to be a competitive method of NO_x reduction at this time, so that the preferred Navy method for diesel engines has not been decided.

The credibility of water-injected, or recirculating-exhaust-gas engine systems, within the Navy community, as a viable alternative for acceptable NOx reduction in the emissions of Navy power plants may be achieved only through a realistic shipboard evaluation. It is the objective of this project to demonstrate the aforementioned naval, at-sea, operating scenario for NOx reduction.

Prior to any shipboard installation, the water-injected combustor system for gas turbines will be tested in a land-based LM2500 simulation facility in Philadelphia, PA. Pending successful resolution of the land-based tests, a water-injection manifold, an electronic water-feed control system, and NOx-monitoring equipment will be integrated with a single LM2500 engine aboard a DDG51-class destroyer. Levels of NOx reduction in gas turbines by means of water injection will be evaluated in a shipboard configuration aboard the destroyer during a routine mission.

In collaboration with contractors, we will explore modification of shipboard diesel engines for water injection at land-based facilities. Tests will address fuel-injector erosion, and corrosion; and methods of mixing fuel to avoid the unpredictable effects of slug flow and flame quenching, with consequent cylinder misfire, and loss of power.

The delivered products will include a credible statement of water-injection system characteristics, preferred control systems, engine-room layouts and a cost assessment of water-injected systems for NOx reduction. Considering test data, we will identify the most cost-effective approach to water injection for emission reduction. If no serious technical

problems arise, a set of management recommendations for transitioning the program to technical evaluation, etc., will be part of the final report.

Thus far, our evaluation group has chosen a supplier for the water manifold and controller, and our milestone for this task is ahead of schedule. Also, we have completed a test of water-fog injection into the bellmouth of the LM2500, which appears to achieve NOx reduction with no significant reduction in thermodynamic efficiency. Evaluation of the preferred NOx reduction scheme for diesel engines is underway.

Combined Noise Model for Community Response; Continuous and Impulse Noise

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Preservation of the Department of Defense (DoD) training, testing and readiness mission requires that DoD be capable of controlling, assessing, managing and monitoring noise problems in the vicinity of its bases and installations. The DoD cannot now consistently do this. It faces continual challenges to current and planned operations because of negative community responses to the noise created by weapons, helicopters, and aircraft. The direct impact is an insidious loss of training and readiness capability through the closure of ranges and firing points, altered flying routes and less realistic training procedures, and nighttime curfews. Equally important are delays due to procedural or litigational challenges to environmental impact analysis documents for proposed changes in operations such as introduction of a larger battle tank main gun, introduction of supersonic flying in an area not previously exposed to these operations, etc. In just one facet of this problem, the DoD has been receiving major challenges to environment impact analysis documents because we do not currently address the combined and cumulative effects of Army and Air Force operations.

The DoD requires the ability to assess the combined/cumulative impacts of joint and/or co-located installations and operations. But there is a lack of adequate scientific data on the effects of environmental noise from DoD operations on the health and welfare of people. Most current community (annoyance) impact assessment methodologies for predicting the effects of aircraft noise on humans rely on annualized average exposure descriptions. These annualized procedures are the day-night A-weighted sound level for fixed-wing aircraft, motor vehicles and most continuous industrial noises. A separate annualized procedure, C-weighted day night average level is applied to blast noise and sonic booms. No method exists to combine these two procedures into one overall assessment. Further, there are serious questions about the efficacy of the current C-weighted procedure for blast and sonic-boom noise. The present standard assessment methodology does not address these issues. Also, no standard method exist to assess small arms noise and other similar highly impulsive sounds. This R&D program is developing impact assessment methodologies that are appropriate for the types of sound, types of operations, and background setting rather than simply relying on one general methodology that may not apply equally well to all circumstances.

Turbulent Boundary Layer Effects on Sound Propagation

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One of the challenges in predicting the noise generated in the vicinity of DoD bases and installations is the effect of the weather on sound propagating away from training activities. Some standard methods for environmental noise assessment assume that average sound levels may be predicted by assuming the most favorable conditions for sound transmission outdoors. Clearly, this over estimates the predicted noise load and can restrict training activities unnecessarily. Our goal is to develop more comprehensive engineering guidelines that account for the effects of weather on sound propagation.

Modeling the sound transmission outdoors in conditions which are not favorable for propagation requires inclusion of the effects of sound scattering from atmospheric turbulence, complicating an already difficult problem. The scattering provides an upper limit to the attenuation and is often the most important effect to consider. Newer computational facilities and experimental measurements have made the modeling tractable and comparisons with measurements possible.

Fundamental Studies of Thermal, Plasma, and Photochemical Processing for Waste Disposal Applications

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The potential of plasma-based technologies for various dual-use environmental compliance and clean-up applications is very high. This is evidenced by a growing number of plasma reactors that are entering the commercial marketplace or are in the latter stages of prototype development in the USA, and especially in Europe and Japan. It is generally recognized, however, that the transition of laboratory plasma reactor technology into the commercial marketplace is being significantly hampered by a lack of understanding of many of the important fundamental plasma processes, particularly plasma chemistry. This lack of understanding precludes any predictive capability of scale-up behavior with regard to toxic compound destruction efficiency, desirable product formation and recovery, as well as the reduction of unwanted plasma by-products. The purpose of this project is to address these significant shortcomings by developing plasma reaction models based on fundamental kinetic and thermodynamic data. These models are validated by experimental diagnostics which map decomposition chemistry inside the plasma reactor and in the effluent region. Unfortunately, progress on this project has been temporarily halted due to the lack of continued SERDP funding beyond the first year.

The plasmas can be broadly divided into two categories; thermal plasmas such as the plasma arc and non-thermal plasmas such as coronas and silent discharges. The former is used primarily for solid waste destruction and the latter for toxic gas control. We have chosen to concentrate on a particular environmental compliance problem facing the Army as well as other services, namely the control of fugitive Volatile Organic Compounds (VOCs) resulting from typical depot operations such as spray painting, paint drying, and paint stripping. Our research strategy is based on the notion of building up the chemical complexity of the plasma reactors by starting with hydrocarbon chemistry and then adding on halogen and other chemistries.

This one-year effort has already generated significant results both in modeling and data base development, as well as in experimental diagnostics. On the modeling side, we initially developed detailed models for the destruction of benzene and toluene and evaluated the available thermodynamic and kinetic data. In particular, we focussed on (1) the identification of the initiation processes, i.e. how is the toxic compound destroyed, is it energetic electron induced bond-breaking or radical attack, and (2) the identification of neutral and ionic reactions, i.e. what is the mechanism of the process? For toluene we have determined that data exists for only 20% of all important electron capture reactions, 50% of excited state reactions, and about 60% of the required thermochemistry. Even with these gaps, initial modeling of toluene destruction has yielded important insight into toluene plasma chemistry. On the experimental side, we have utilized degenerate four-wave mixing (DFWM) spectroscopy for in-situ diagnostics of the C_1 and C_2 hydrocarbon radicals and OH in a pulsed corona reactor. This non-intrusive optical diagnostic technique uses three input laser beams which are crossed inside the reactor and when on resonance with the species of interest they generate a fourth beam, a coherent signal beam that is detected remotely from

Fundamental Studies of Thermal, Plasma, and Photochemical Processing for Waste Disposal Applications (cont'd)

the discharge. The DFWM technique provides unique capabilities for mapping species' temperature and concentration.

In addition to the specific work listed above, we organized a major workshop on the Treatment of Gaseous Emissions via Plasma Technology: Present Status and Future Needs in March 1995 at NIST. Attendees included representatives from industry, various government agencies, universities, and the topics covered the full spectrum of technology development from fundamental data needs to market and economic aspects. The results of this workshop will be presented at the poster.

Co-Investigators: Drs. J.T. Herron, D.S. Green, W.G. Mallard, J.W. Hudgens, and W. Tsang, NIST, Prof. J.S. Chang, McMaster University

Technical and Economic Assessment of Storage of Industrial Waste on Abyssal Plains

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The Naval Research Laboratory (NRL), with industry and academic participation, has completed an assessment of the concept of isolating (storing) industrial wastes (i.e., sewage sludge, fly ash from municipal incinerators, and dredged material) on the oceans' abyssal seafloor. In this assessment, the advantages and disadvantages, economic viability, and environmental impacts of potential isolation techniques were identified and assessed.

The technical assessment began with identification of 128 patents addressing waste disposal in the ocean. From these 128 patents, five techniques for transporting wastes through the water column and emplacing wastes within an easily monitored area on the abyssal seafloor were synthesized for technical assessment. One of these, using a 190 m^3 bucket to lower waste to the seafloor, was found to be the least cost effective by an order of magnitude. A second, pumping the waste down 1.37 m diameter pipes, 6100 m in length, was shown to be fraught with technical uncertainties and was also not cost competitive. The remaining three techniques, all shown in preliminary analyses to be technically viable and cost comparable, are: (1) free-falling the waste from the ocean surface in 380 m^3 synthetic fabric containers, and carrying similar waste-filled containers to the seafloor in (2) a 20,000 metric ton displacement (loaded) unpowered submarine glider or (3) a 2085 metric ton displacement (loaded) disk-shaped transporter traversing to and from the seafloor much like an untethered elevator. Risk analyses show that the free-fall fabric container poses the least technical risk, provided that fabric container and transporter designs eliminate the potential for tearing of the containers on release from the surface transporter. All three viable techniques are shown to offer cost effective waste management options when compared with present-day waste management techniques in higher-priced areas, such as the New York-New Jersey area.

The environmental assessment portion of the project sought first to identify optimal areas which maximize environmental isolation of wastes on the abyssal seafloor and second to assess impact of proposed waste emplacement on such optimal areas. A PC-based site assessment model was developed to quantitatively compare the suitability of 1°-squares of the seafloor for waste isolation. Included in the analysis were environmental and anthropogenic factors. Areas in the Hatteras Abyssal Plain (Atlantic) and the abyssal hills area west of southern California (Pacific) were shown to be the most suitable, while least suitable areas were identified in the Gulf of Mexico. Biological and chemical conceptual and numerical models describing the impact of emplacement of large quantities of organic wastes on the abyssal seafloor were developed. The biologic model showed that existing fauna would be quickly displaced by a less diverse benthic community in the immediate area of a waste mound. Return of the benthic community to a new equilibrium condition can be expected to take 100's to 1000's of years. The geochemical model showed geochemical processes in the original seafloor to be profoundly altered for 1000's to ten's of 1,000's of years. Such profound geochemical impact in the immediate locale of a waste isolation site is expected to stay local to the site. Contaminants in the waste materials are expected to remain adsorbed to sediment particles, but may enter the deep-sea food chain via deposit-

Technical and Economic Assessment of Storage of Industrial Waste on Abyssal Plains (cont'd)

feeding animals. Only one potential pathway for contaminants to leave the abyssal ocean depths has been identified: transport in the yolks of eggs of demersal fish species. The eggs (gonads) of some fish species are known to rise to shallower water depths where they could be consumed by other species closer to food chains utilized by humans. The potential for measurable transport via this pathway is believed negligible, but certainly merits thorough evaluation.

In conclusion, the abyssal seafloor waste isolation concept is technically feasible and cost-effective for many waste sources, and is potentially acceptable from an environmental point of view.

Non-Ozone-Depleting Refrigerants for Navy Chillers

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The U.S. Navy has undertaken an extensive evaluation of alternative refrigerants for use in shipboard chillers. This has been necessitated by the understanding that refrigerants such as CFC (chlorofluorocarbon) 114 are potentially damaging to Earth's stratospheric ozone layer. The Navy has traditionally used this refrigerant in its surface and submarine fleet for chillers. The initial evaluation of alternatives for retrofit applications resulted in refrigerants either that the Navy was unable to obtain or that were hydrochlorofluorocarbons all of which have some ozone depletion potential. Through the Strategic Environmental Research and Development Program (SERDP), the Environmental Protection Agency and the Navy joined in an effort to evaluate zero-ozone-depleting refrigerants that could be available in the required time. This resulted in two isomers of HFC (hydrofluorocarbon) 236 receiving the most attention as acceptable alternatives. HFC-236ea and HFC-236fa have both been tested in Navy chillers and both are undergoing toxicity testing at this writing. The Navy intends to make its final selection of a refrigerant for retrofit applications prior to the April SERDP meeting. It is anticipated that, if the entire fleet is retrofitted with either of these isomers, $500 million would be saved over having to replace the entire chiller in each ship.

Solid Particulate Aerosols
A New Method for Powerful, Economical Fire Suppression

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A new class of fire suppressants, known generally as solid particulate aerosols (SPA), having superior volumetric efficiency, low initial and life cycle costs, low toxicity, no known global atmospheric environmental impacts (ODP/GWP), and with the potential for a wide variety of applications, is being developed in a variety of private and public sector programs. These research programs consist of developing solid compound formulations that, when pyrotechnically initiated, generate powerful fire suppression aerosols that behave as lighter than air gases. Preliminary indications are that these aerosols as much as six times more powerful as fire suppressants that Halon 1301 on a mass basis. Using a solid, gel, or powder as the starting point for generation of an aerosol eliminates the need for piping and pressure cylinders, creating a potential for application in a wide variety of fire suppression roles: facilities, aircraft cargo containers, portable rapid deployment shelters, fuel storage tanks, battery/UPS rooms, unmanned telecommunications facilities, and armored vehicle engine compartments. The speed of aerosol formation is dependent on system design and configuration. Mechanisms of aerosol fire suppression are discussed and the most recent test results are presented. The Air Force is proceeding on a multi-track effort to both investigate the basic science of solid particulate aerosol fore suppression technology as well as to initiate the engineering of practical devices that exploit the potential advantages is investigating particle size distribution, mechanisms of fire suppression, aerosol suspension dynamics to include stratification, and effectiveness against Class A, B, C, D fires. The effort is investigating the thermal characteristics of SPA materials, methods and materials for absorbing the thermal output of combusting SPA, aerosol cooling techniques and flame suppression methods. The engineering of a hand-thrown, 0.5 Kg device for use for immediate action in combating a fire with a volume of 10 m^3 is the hoped for initial outcome of the current work plans.

Reduce VOCs and HAPs from Painting and Cleaning Operations

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In 1993, the SERDP office approved a research program that is designed to provide a comprehensive pollution prevention strategy for military depot facilities. The research and development is being conducted by a consortium comprised of the USMC, Penn State University/Applied Research Laboratory (ARL), and the USEPA. The program will develop and evaluate innovative manufacturing and emission control technologies that manifest a pollution prevention philosophy to reduce total emissions from manufacturing and maintenance processes. The program will concentrate on painting and surface cleaning operations which represent greater than 75 percent of the total pollutant emissions from typical Department of Defense facilities.

The program is divided into two parts. First, innovative pollution prevention technologies for painting and surface cleaning processes will be identified. Full scale demonstration of acceptable alternatives will follow. Anticipated technologies to be studied and demonstrated include ultra low volume (ULV) paint technology, which is predicted to reduce paint use and emissions by 25 percent; and n-methylpyrrolidone (NMP), a solvent substitute alternative for methylene chloride.

Second, simultaneous R&D studies will be conducted on the use of ultraviolet (UV) radiation destruction of volatile organic compound emissions. Fundamental and applied research will be conducted at Penn State University's ARL, utilizing a 2000 cfm pilot scale laboratory system. The results will be transferred and implemented in a full scale 45,000 cfm demonstration system. An integral part of this demonstration is the full scale validation of the exhaust flow management concept called recirculation and partitioning. This concept will reduce the control system treatment volume from 120,000 cfm to 45,000 cfm. This booth design concept will significantly reduce the cost of operating emission control technologies for paint spray booths. Based on previous EPA manufacturing technology studies, it is projected that this program will result in a pollution prevention strategy that will reduce emissions from a typical depot operation by greater than 50 percent.

This paper presents the scope of the program and the projected savings that will result from the technology development and demonstrations proposed for the program. For further information about this work, you may contact Charles H. Darvin (919) 541-7633.

High-Performance, Lead-Free Electrical Sealants

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Electrical grade polysulfide is used extensively in high performance applications for sealing, bonding and coating. This type of polysulfide is used because it has numerous desirable processing and material property characteristics: low mix viscosity, low cure temperature (often room temperature), long working life, stress relief for encapsulates, good adhesion to many materials, excellent elastomeric properties at low temperatures (-55°C), and the best electrical properties within all other classes of polysulfide materials. However, this material has a number of environmental drawbacks which make it unacceptable for future use from both processing and disposal. Electrical grade polysulfide contains lead oxide as a curative, a hazardous material which will potentially undergo very strict regulations (Lead Exposure Act of 1991 and the Clean Air Act of 1990) in the near future. Also, it has cure rate which is sensitive to humidity. The excess material from processing must be disposed of as a hazardous waste and the cure rate conditions are uncontrollable because vendors are unable to obtain consistent lead oxide.

Electrical grade sealants are used in many military applications, as well as automotive applications, e.g., fuel tank sealants, corrosion inhibitive sealants, and stress relief for encapsulants. With a solvent-free, organic based curative, a low-cost replacement for the silicone encapsulant used in solar concentrator panels could be achieved. The usage would be 200,000 lb. per 100 MW. An government interagency task force, consisting of the principle users (DOE and GSA), was formed in late 1992 to develop a lead-free drop-in material, i.e., an environmentally safe material meeting as many of the desirable material and processing characteristics as possible. I will summarize our program and the interagency's progress.

Fluorinated Ship Hull Coatings for Non-polluting Fouling Control

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The overall goal of this project is to develop non-polluting, easy fouling release, hull coatings based on flexible, low-surface-energy polymers. Ship hull protection from marine fouling organisms is essential for efficient fleet operation and energy conservation. Presently, the Navy standard antifouling (AF) coating contains copper compounds as a toxicant, which may create an environmental hazard and potential for pollution. Low surface free energy coatings work by a physical property of the solid surface rather than toxicity of released antifouling agent. Since nothing is released into the environment, there is no risk of environmental pollution.

Such coating have a significant potential for reducing costs associated with dry-dock and in-water hull cleaning operations. They could also result in less degradation of operational performance due to fouling drag between scheduled hull cleanings.

Our approach takes advantage of the weak adhesion characteristics of materials that have low surface free energy. All marine fouling organisms use some sort of adhesive for attachment to solid surfaces. However, the lower the surface energy of the solid, the weaker is the adhesive bond. We have bound perfluorinated compounds into a polymeric backbone to create a comb type polymer with perfluorinated alkyl sidechains. Our polymer formulations include acrylate based copolymers polymerized from varying ratios of acrylate/methacrylate monomers. Critical technical issues which will be addressed include the surface orientation of the molecules and fluorinated side-chains and the degree of polymer flexibility which can be achieved without sacrificing toughness/durability. Emphasis will be placed on optimizing the polymerization process; minimizing variability in preparing and testing samples; and correlating surface and bulk characterization data with the coatings actual fouling-release performance. These correlation studies will allow the design of new polymer formulations with maximum fouling-release properties.

This Technology will be transferred into a demonstration program for field ship trials with industry involvement. Successful coating formulations can be implemented very quickly by the paint manufacturing industry.

Metallurgical Bonding Using Railgun Technology Electromagnetic Powder Deposition

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Electromagnetic Powder Deposition (EPD) is a process by which a metallurgical bond is achieved by accelerating a deposit material to high velocity and directing it to impact with a target, or base material. The deposit material is transformed from a solid state such as powder, wire, or foil, to a mixture of plasma and liquid droplets by a short duration (10^{-6} sec), High current (80,000 amp) electrical pulse. Then, using railgun technology, this "plasma cloud" is accelerated to a velocity greater than 2 kilometers per second before being deposited on the base material. Preliminary experiments, conducted by the Center for Electromechanics (CEM) at the University of Texas (UT) in Austin, identified that the EPD process is capable of achieving a coating of deposit material with bond strength equal to the base material while achieving less than 3% porosity. The impetus for developing the EPD process stems from economical and environmental constraints imposed by existing repair methods for jet engine components. Currently, the Air Force is dependent on welding and plating processes using materials such as nickel and chrome, to rebuild distorted or worn jet engine components. Welding processed normally causes excessive distortion and plating processes are labor intensive and produce hazardous waste. Furthermore, due to the inherent limitations of the plating process, extensive machining and secondary or tertiary plating cycles are standard procedure. However, repair facilities within the Department of Defense (DoD) and throughout the commercial industry are currently dependent on chemical plating and welding processes to rebuild worn jet engine components. In part to streamline the repair process and because of stricler hazardous waste disposal and reduction regulations imposed by the government, there exists an immediate need to find alternative repair methods. Therefore, the need for a low heat input, non-hazardous, high throughput production deposition process has been given a high priority within the Oklahoma City Air Logistics Center (OC-ALC). The goal of the EPD program is to develop an environmentally safe, high throughput fusion plating process capable of rebuilding distorted or worn jet engine components within a production oriented repair and manufacturing environment. When fully developed, the EPD process has broad commercial applications as it may be used to replace existing plating and cladding processes for both thin and thick coating operations using various materials . Funding for this project was provided by Strategic Environmental Research and Development (SERDP) Program. This work is being performed under the auspices of the U.S. Air Force by ARINC.

An Environmental Knowledge-Based Advisor for Facilities Life Cycle Decisions

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The goal of this project is to provide the design and construction communities in both the public and private sectors with a set of tools which will enable the consideration of environmental factors over the life cycle of a typical building. Currently, building decisions such as design, construction, operation and renovations, and demolition, are made based primarily on economic and in-place performance data. Environmental factors, such as embodied energy, natural resource depletion, indoor air quality, waste products, etc., are not considered in any of the current technical, pricing, or planning data used as the basis for these decisions. The inclusion of such factors are essential in optimizing the standard facility decision processes and obtaining the maximum benefits from limited natural and economic resources while reducing the potential for adverse environmental impacts. The objectives of this project are: 1) to develop and field test a knowledge-based model of environmental attributes which can support the decision processes involved in facility design, construction, and operation and, 2) to place on the Internet a life cycle assessment database (LCA) for building materials which can provide continued support for the system. The Environmental Knowledge Based Advisor (EKBA) is an artificial intelligence engine that employs Cased Based Reasoning and Object Oriented Programming to facilitate decision making. A prototype of the model has been developed which has successfully demonstrated the feasibility of the project. Development has begun on the LCA database for building materials. The database will be housed on the Internet and will provide the proposed EKBA, as well as other potential users, such as ASTM, the American Institute of Architects, green products manufacturers, etc. with ready data source. The Internet LCA database will also be interfaced with an independent set of decision support software currently under development by the Nation Institute of Standards and Technology (NIST). The Internet LCA database coupled with the NIST software will provide the EKBA and other potential users with a continuous source of LCA information related to building materials. Funding for this project is provided the Strategic Environmental Research and Development Program (SERDP). The work is done under the auspices of the U.S. EPA Air and Energy Engineering Research Laboratory, SERDP Project number SERDP 307-94.

The Solvent Alternatives Umbrella: Linking and Synthesizing Information on Solvent Substitutes easily through the Internet

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DoD facilities and supporting industries need fast easy access to integrated network information on available substitutes to meet the impending phase outs of ozone depleting substances (ODS), and reduction of toxics under the Clean Air Act, and Executive Order 12856. The Enviroene network has been developed as a distributedly managed system to relay pertinent technical pollution prevention information to all federal agencies and specifically to house an expert architecture known as the Solvent Umbrella. The Solvent Umbrella will utilize state of the art electronic navigational, translation, and search tools in the Internet environment. The Umbrella will allow users to access solvent alternative information through a single easy to use command structure which will seamlessly access and retrieve information from its component data bases. The Umbrella's command structure will tap into data bases resident on Enviroene, as well as remote data bases linked through Internet. The search engine of the Umbrella will allow user queries to be ranked through a decision tree structure, and will generate weighted search results based on the users process specific needs. The level of information synthesis performed by the Umbrella will reduce the amount of research and testing but will not eliminate evaluation necessary by the user before implementing a substitution. The Umbrella is employing an architecture using decision tree programming, Netscape@ navigational software, Topic@ search and retrieval software; and translational programming based in part on that developed through DOD's Omniport project. The Umbrella is expected to be completed (with at least 6 phase 1 data bases) by the end of FY95. Segments of the Umbrella have been completed, with a linked search of at least three of the component data bases to be demonstrated during the SERDP conference in April 1995.

The Umbrella will link a number of federal, state, and private database tools. A sample of the data bases to be included in the Umbrella include: EPA's Solvent Alternatives Guide (SAGE); INEL's Hazardous Solvent Substitution Data System (HSSDS); INEL's Solvent Handbook Data System (SHDS); NFESC's P2 Library ODS and Solvent Alternatives data bases; NCMS's Compatibilty and Solvents data bases; NMERI's Halocarbon database; and EPA's Enviroene integrated Vendor database. The umbrella will allow the user to tap into applicable Mil Specs, TO's, National Stock Numbers, and Material Safety Data Sheets where appropriate. The Enviroene network and its component Solvent Umbrella will be deployed through DOD Service Environmental Centers, Bases, Depots, Education Centers, and Supply Centers through targeted solvent and P2 workshops with computer training sessions designed to leave attendees fully equipped with hardware, software, and Internet connectivity.

DoD/DOE Clean, Agile Manufacturing of Energetics

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Approximately 100 million pounds of propellants, explosives, and pyrotechnics (PEP) are produced each year for DoD, DOE, and NASA as main charge explosives, solid rocket propellants, and flares/illuminators. PEP used by the Defense community are required to have their hazardous wastes reduced by at least 50% by 1999. DOE and NASA also have PEP waste reduction requirements. PEP chemicals and products are produced in government operated, GOCO, and defense contractor facilities. Ever stricter environmental regulations and waste restrictions could force some PEP chemicals out of the ordnance inventory. As public concern about waste generation increases, it becomes less likely that the military would be exempted from compliance with environmental regulations on the basis of national security. This SERDP program is a five year technology demonstration effort initiated by the Office of the Director, Defense Research and Engineering and endorsed by the SERDP Scientific Advisory Board in January, 1993. The objective of this program is to: develop and demonstrate in pilot plants/factories the feasibility of technologies; provide a 90% reduction in total PEP life cycle pollution across weapon/system inventory; enable such a reduction through "agile" use of existing factories; and provide mechanism for integration of PEP environmental life cycle assessment methodology into ordnance acquisition process. Life cycle models and simulations are being developed to predict life-cycle pollution, performance, costs and risk. Pollution prevention technologies and new facility concepts are being experimentally tested in existing laboratories and facilities. The following areas of technology development and demonstration are being pursued: life-cycle assessment simulation tool; new materials and processes to prevent pollution; demonstration of critical pollution prevention technologies by the project team; and plan for single manager's clean, agile PEP virtual enterprise. To date, the project team has selected life cycle assessment tools to use in establishing environmental baseline for measuring progress; completed 1st phase life cycle inventory of an RDX product; and identified and began development of materials and processing technologies. The main thrust of continuing technology development under this program are in materials and processing technologies and in further development of life cycle simulations and models. In particular, the project is pursuing: explosive and propellant recovery using oxetane thermal plastic elastomer (TPE) and/or melt castable TNAZ; energetic oxetane synthesis in supercritical CO2; advanced nitramine pilot plant demonstration; and advanced processing modeling and control demonstration.

A Novel Water Purification Technology
Capacitive Deionization with Carbon Aerogel Electrodes

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The capacitive deionization (CDI) of water with a stack of carbon aerogel electrodes has been successfully demonstrated for the first time. Each carbon aerogel electrode has an exceptionally high specific surface area (400-1000 m2/gm). The demonstration system consists of 384 such electrodes, giving it a total active surface area of one billion square centimeters. Water with various anions and cations is pumped through the flow-through electrolytic supercapacitor. After polarization, ions are electrostatically removed from the water and held in the electric double layers formed at electrode surfaces. Water leaving the cell is purified. This new technology has several important potential applications. Ultimately, CDI could be used for desalination of sea water. The CDI system is orders of magnitude more energy efficient than competing processes such as evaporation and reverse osmosis. Furthermore, no troublesome membranes are required. It could also be used for the removal of various ions from waste water without the generation of secondary acid, base, or salt wastes. Ion exchange is now used for the treatment of contaminated rinse water from metal finishing operations, as well as for the treatment of aqueous streams laden with radioactive materials. Saturated ion exchange columns require concentrated acids, bases, or salt solutions for regeneration. Since electricity is used for regeneration of the CDI system, no such secondary waste is generated. The need for such technology is great. The United States Department of Energy (U.S. DOE) has an inventory of approximately one billion liters of NaNO3 solution contaminated with 137Cs, 90Sr, and other radioactive materials. CDI is ideal for the treatment of boiler water in nuclear and fossil power plants. Such treatment is essential for the prevention of pitting, stress corrosion cracking, and scaling of heat transfer surfaces. CDI systems could be used as electrically-driven water softeners in homes. Such systems would soften home drinking water without the introduction of sodium chloride. A conventional domestic water softener uses sodium chloride to regenerate a bed of ion exchange resin. Since people on low-salt diets require low-salt water, reverse osmosis has to be used downstream of the ion exchanger to remove the sodium chloride introduced during regeneration. CDI does not require salt additions for regeneration and would not have to be followed by a reverse osmosis system. Funding for this project was provided by the Strategic Environmental Research and Development (SERDP) Program. This work was done under the auspices of U.S. DOE by Lawrence Livermore National Laboratory (LLNL) under Contract No. W-7405-Eng-48.

Purification / Recycling of Plating and Cleaning Baths

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Electroplating shops use process solutions containing hazardous materials for plating, acid etching, pickling, alkaline electrocleaning, chromating, anodizing, and other metal finishing operations. The effective life of metal finishing process solutions is limited by the increasing levels of contaminants that are drug in from the parts being plated or cleaned. Large volumes of concentrated hazardous wastes are generated from process solutions that become spent due to buildup of contaminants. The Naval Facilities Engineering Service Center working under the support of the Strategic Environmental Research and Development Program has been tasked to develop technologies that can be used to maintain and extend the service life of metal preparation and finishing baths. The effort is being conducted in partnership with Air Force's Wright Laboratory and EPA's Risk Reduction Engineering Laboratory. The overall program will address removal of contaminants from several process solution types including alkaline cleaners, chrome solutions, acid and alkali etches, and electroless nickel baths. Test and evaluation of separation technologies including membrane electrolysis, ion transfer, diffusion dialysis, electrodialysis, adsorption and microfiltration are being conducted. In this presentation, the results of field studies conducted with ion transfer and membrane electrolysis technologies applied to chromic acid solutions will be highlighted. Development of in-line bath maintenance systems could prolong effective process bath life by up to 30 fold. Navy, DoD and industry plating shops will benefit.

Laser Ignition to Replace Chemical Ordnance Igniters for Propulsion

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The standard initiator for propelling charges in U.S. 155 mm weapon systems is the M82 percussion primer. Conventional ignition systems use impact or electrically initiated primers to transfer energy to igniter material. The chemical ignition materials used in gun propulsion consist of various high explosives, lead azide, blackpowder, nitrocellulose-based propellants, benite, $BKNO_3$ and other pyrotechnics. This work deals with an effective means to eliminate hazardous components in ordnance. An ignition system that consists of a Nd:YAG laser, optical fiber and sapphire window which has been incorporated into the gun breech spindle is being developed. The laser igniter is compatible with all existing self-propelled and towed cannons as well as developmental propulsion systems such as unicharge. Problems associated with the disposal of ignition materials will no longer exist when lasers are integrated as the primary gun ignition source. Demilitarization of the vast inventories of these sensitive materials via incineration is dangerous and can produce pollutants, carcinogens and toxic agents. There are also safety considerations in the manufacture, handling, storage, disposal or recycling of these energetic materials which greatly impact cost. Furthermore, the laser can reliably ignite the propelling charge at all stand off distances, eliminates all electrical connections to the gun chamber for safety, reduce overall vulnerability of the propulsion system, and the laser can be fully computer controlled to avoid accidental off-target firing of the weapon.

An overview of the optical configuration, laser system development and results of parametric investigations on the effect of laser pulse length, energy and wavelength on the ignition threshold and ignition delay of energetic materials will be presented. The results of full scale interior ballistic simulator experiments and gun firings obtained at all temperature extremes and loading configurations demonstrate excellent flamespreading and performance characteristics.

Nine Small Business Innovation Research (SBIR) projects and two Cooperative Research and Development Agreements (CRDA) are funded to develop compact lasers, optical fibers and component parts of the laser ignition system. All have excellent Dual/Use technology transfer application spin-offs and numerous commercial products are under development. This technology is strongly supported by the Program Executive Office-Field Artillery System, the Program Manager-Advanced Field Artillery System (PM-AFAS), the Product Manager-Paladin, ARDEC and MRDEC.

Funding for this project was provided by the Strategic Environmental Research and Development (SERDP) Program, Project E209.

The Quantitative Ion-Exchange Separation of Uranium from Impurities

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Two methods were tested for the quantitative separation of uranium from elemental impurities using commercially available resins. The sorption and elution behavior of uranium and the separation of it from a variety of other elements was studied. The first method utilized an anion exchange resin while the second method employed an extraction resin. The first method, the anion exchange of uranium (VI) in an acid chloride medium, was optimized and statistically tested for quantitative recovery of uranium. This procedure involved adsorption of uranium onto Bio-Rad AG 1-X8 or *M*P-l ion exchange resins in 8 *M* HCl, separation of uncomplexed or weakly complexed matrix ions with an 8*M* HCl wash, and subsequent elution of uranium with 1 M HCI. Matrix ions more strongly adsorbed than uranium were left on the resin. Uranium recoveries with this procedure averaged greater then 99.9% with a standard deviation of 0.1%. In the second method, recovery of uranium on the extraction resin did not meet the criteria of this study and further examination was terminated. POC- Pete Mason

Isotope Dilution Mass Spectrometric Analysis of Uranium

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This report describes the feasibility of performing uranium isotope dilution mass spectrometry (IDMS) utilizing spike materials of either high ^{233}U. The technique, as developed and qualified, will allow laboratories to perform uranium IDMS measurements on all levels of depleted, natural, or enriched uranium materials without the necessity of dealing with the highly alpha-radioactive ^{233}U isotope. The IDMS method has demonstrated accuracy and precision levels of better than $\pm$0.25% relative standard deviation. As compared with conventional titrimetric methods for uranium analysis, this method results in a minimum tow-fold reduction in waste generation and the elimination of a RCRA waste.
POC- Pete Mason

Database Application for Input and Review of Information on Analytical Measurements

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An Analytical Measurements Information Database Application was developed to give an overall view of the criteria involved in the selection of an analytical measurement technique. This specific database application was developed for the measurement of elemental concentration of uranium. It includes information on many components of each measurement technique and allows easy comparison of different techniques. The integrated data information for the methods contained in this program include the specific technique, expected precision and bias, materials applicability, interferences, analysis time, reagents needed, training time, instrumentation required and its associated costs, and resulting process streams.

The process stream information may be used to determine the method of preference based on pollution prevention opportunities. Use of this information also serves as an up-front indication of types of wastes generated when different information also serves as an up-front indication of the types of waste generated when different analytical methods are implemented. Most sites, through pollution prevention programs and departmental mandates, are required to generate annual waste forecasts. The use of the process stream information greatly reduces the difficulty of predicting waste generation rates for different analytical methods, while the accuracy of such predictions is substantially increased. POC-Pete Mason

Lubrication Free Centrifugal Compressor

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This program is demonstrating the benefits of an innovative, lightweight, lubrication free centrifugal compressor for a vapor compression heat pump system that allows the use of environmentally safe alternate refrigerants with improved system efficiencies over current State-of-the-Art technology. This effort is developing 3-D bladed high efficiency centrifugal compressor technology and coupling it with magnetic bearing technology and will then prove the performance, life and reliability of the compressor.

The manufacture of CFCs will be halted by 1 January 1996 and HCFCs will be the next to be totally phased out. All DoD vapor compression environmental control systems use these refrigerants. The proposed environmentally safe alternate refrigerants (e.g., R-134a) are inherently less stable than the currently used CFCs, so that they break down in the lower atmosphere, and thus do not degrade the ozone layer. These refrigerants have zero ozone depletion factor. The addition of lubricants further lowers stability. In the pure state, these fluids remain relatively stable to temperatures up to 370°C. But, the presence of oil lowers the stability limits to below 100°C. The oil unfortunately acts as a catalyst for the decomposition process, which means they will more readily decompose within the refrigeration cycle hardware. This can preclude the use of vapor compression cycle technology unless compromises are made that substantially lower efficiency, reliability and lifetime.

The vapor compression heat pump remains the most efficient refrigeration and air conditioning cycle available. Rather than discarding this cycle for less efficient cooling cycles such as magnetic refrigeration, Stirling, Brayton, thermoelectric, or a rash of others, the development of a lubrication free compressor would allow the well known vapor compression cycle to be used without destroying the ozone layer. Removal of the oil means very good HFC refrigerant stability. Furthermore the use of one of these "NEW" cycles will mean retraining the heating, ventilation, and airconditioning (HVAC) technician community, retrofitting the existing HVAC and refrigeration units in the country, sacrificing efficiency, and costing more to procure, operate and maintain.

The commercial applications of this technology are vast. This technology is directly applicable to the residential and commercial heat pump market, primarily because it is not only environmentally enhancing, but also provides considerable energy efficiency and energy cost benefits. Another benefit of this technology is that only the compressor system and working fluid need be changed to make currently operating systems environmentally friendly. This has huge cost saving ramifications.

To date, Mainstream Engineering Corporation, under Contract F33615-94-C-2407 to Wright Laboratory has made profound progress in developing a complete low flow rate centrifugal compressor design theory with significant progress in increasing compressor efficiency. Funding for this project is being provided by the Strategic Environmental Research and Development (SERDP) Program.

Aircraft Depainting Technology

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The objective of the Aircraft Depainting Technology effort is to develop non-hazardous replacements for chemical paint stripping use on Navy aircraft, weapon systems and ground support equipment. Current chemical paint strippers contain hazardous components like phenols, methylene chloride and chromates. Paint removal operations at maintenance depots has been determined to be a major contributor to hazardous waste generation in the Navy. Several generic alternative methods to the present chemical removers are being developed to cover all three levels of Naval Aviation Maintenance stripping processes. This program has investigated the best alternatives from existing and developmental methods. For depot level operations (i.e. large production scale), a hybrid approach combining flash lamp and dry ice stripping (FlashJet) is being developed and service demonstrated at NADEP facilities. For intermediate level operations, a medium pressure water system (WaterJet) is being demonstrated at the Cherry Point Maintenance facility. Finally, non-hazardous chemical paint strippers (i.e. materials that do not contain chromates, methylene chloride, phenol, etc.) are being pursued for organizational (fleet) level maintenance stripping as well as for spot and touch-up procedures at all levels. This overall approach will meet the Naval Aviation Community's needs while complying with EPA and state/local agencies regulations. In addition, aircraft performance and operational readiness will be maintained through adequate maintenance practices. This effort is supported by the Strategic Environmental Research and Development Program for the R&D portion and the Navy Shoreside Environmental Program for validation and implementation. The requirements for this effort are covered under the Tri-Service Environmental Quality Strategic Plan: Pillar 3 - Pollution Prevention, Requirement Thrust: 3.1.5.a Non-Hazardous Paint Removal.

Aircraft Maintenance Chromium Replacement

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The objective of the Aircraft Maintenance Chromium Replacement effort is to replace chromates (Cr) currently used in aerospace materials and processes on Navy aircraft, weapon systems and ground support equipment. Chromated materials used in production and depot level maintenance operations are a large contributor to the overall hazardous waste generated by the Navy. Several finishing processes were targeted for replacement. These include anodizing, surface preparation, pretreating, sealing, adhesive bonding and corrosion preventive processes. Sulfuric/Boric acid Anodize has successfully been demonstrated as an alternative to chromic acid anodize. This implementation saves the expense for emission control equipment ($700K capital/facility plus $300K in annual operating costs). Previously, non-chromated alkaline cleaners and deoxidizers were developed and implemented, saving over $20K/year in process costs and eliminating 3 tons of chrome waste/year per facility. Non-chromated adhesion bonding processes are currently being investigated as well as non chromated surface pretreatments for aircraft structures. Chromium VI, a carcinogen, is restricted by federal, state and local environmental agencies through regulations such as the Clean Air Act, Clean Water Act, and local EPA and State rules. In addition, CNO directives require significant reductions in the amount of hazardous waste generated by the Navy. Therefore, in order to comply with these regulations while maintaining aircraft performance and operational readiness, chrome-free alternatives for current processes have to be developed and implemented. The elimination of chromic acid anodizing, chromated alkaline cleaners, and chromated deoxidizers has significantly reduced the total amount of chromium emitted from Navy operations. This work is supported by the Strategic Environmental Research and Development Program for the R&D portion and the Navy Shoreside Environmental Program for validation and implementation. The requirements for this effort are covered under the Tri-Service Environmental Quality Strategic Plan, Pillar 3 Pollution Prevention: Requirement Thrust: 3.1.3.e: Non-Hazardous Alternatives for Heavy Metal Constituents Used in Plating and Finishing.

Organic Protective Coatings and Application Technology

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The objective of the Organic Protective Coatings and Application Technology effort is to develop high performance, non-toxic, low volatile organic compounds (VOC) content coatings for Navy use. Organic coatings are the primary source of protection against environmental degradation for Navy aircraft and they provide passive countermeasures against many enemy threats. There are a large number of different coating systems currently used by the Navy due to the diverse nature of their functions (i.e., variety of substrates/alloys; severe operational environment, etc.). These protective coatings contain toxic inhibitors (i.e. lead, chromates, etc.) and high VOC contents which are released during painting operations as organic and toxic air emissions. A full spectrum RDT&E approach for reducing the VOC and air toxic emissions from protective coatings is being pursued. This includes investigation in low VOC polymer technology to produce low VOC binder systems. Reactive monomers and diluents and low molecular weight resins have been used to develop low viscosity binder systems for future near-zero VOC aircraft coatings. In addition, recent advances in water-borne resin technology has allowed for the development of a high performance water-borne topcoat which goes beyond mere compliance with environmental regulations. Novel non-toxic inhibitor systems have been developed and formulated into non-toxic aircraft corrosion inhibiting primers. Coating corrosion resistance, physical performance properties and VOC content were evaluated in the development of the best materials. The non-toxic inhibited primers have been optimized, and service evaluation at Navy maintenance facilities is in progress. Specification revisions have been completed to implement these materials for Navy use. With increased restrictions (Clean Air Act, etc.) from federal, state and local environmental agencies (EPA, CARB, etc.), the hazardous emissions from current painting operations have to be minimized. Since these emissions are a major contributor to the overall hazardous material and waste generated by the Navy, it is necessary to develop new high performance coatings that meet current and future environmental restrictions and in addition, allow the Navy to continue painting operations. This effort is supported by the Strategic Environmental Research and Development Program for the R&D portion and the Navy Shoreside Environmental Program for validation and implementation. The requirements for this effort are covered under the Tri-Service Environmental Quality Strategic Plan; Pillar 3: Pollution Prevention, Requirement Thrust: 3.1.4.h: Non-Hazardous Aircraft Paints and Coatings.

Life Cycle Engineering & Design Program

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Since 1988, the EPA has managed a technical support effort known as the Waste Reduction Evaluations At Federal Sites (WREAFS) Program. WREAFS was established to provide support to Federal facilities in researching, developing and demonstrating pollution prevention technologies and transferring lessons learned among the Federal community. WREAFS has conducted more than 37 separate RD&D efforts under funding from both EPA and 9 other Federal departments and agencies via interagency agreements. In 1990, Congress established the Strategic Environmental Research and Development Program (SERDP) as a multi-agency effort to support environmental RD&D programs. With SERDP sponsorship, WREAFS has conducted RD&D projects for national defense purposes that assist government and private sector organizations in addressing environmental concerns.

The latest cooperative effort between SERDP and WREAFS is the **Life Cycle Engineering & Design Program.** This program consists of projects to promote the integration of pollution prevention concepts into the design of systems in order to enhance performance, reduce logistics and maintenance requirements, reduce environmental and energy burdens and extend service life. Under this program, SERDP and WREAFS are focusing on depainting alternatives for KC-135 radomes, an evaluation of CARC applications, an assessment of the GBU-24 bomb, and a study under the DOE's alternative feedstocks program.

WREAFS has completed a series of projects under SERDP, from which deliverables are being cleared for publication. Copies of cleared publications from these projects will be available. Draft deliverables undergoing clearance shall be available for perusal at the poster display, and cleared copies will be mailed upon request at a later date.

Solventless Pyrotechnic Manufacturing: The Cryogenic and Cast / Cure Processing Approaches

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Conventional pyrotechnics processing techniques use volatile organic compounds (VOC's) to solubilize binder materials for coating pyrotechnic solids (metal and inorganic salt powders, and the like). Very importantly, VOC's also drastically reduce the hazard ignition sensitivities of the pyrotechnic solids during processing. Excess solvent can then readily be removed from finished pyrotechnic materials simply by evaporation. Our project is concerned with finding safe, effective means of processing military pyrotechnics that eliminate or minimize the use of VOC's as process solvents. Two independent phases, or approaches, are being carried out. Phase I, conducted at NSWC Indian Head, utilizes a cryogenic approach to processing in which the solids are mixed under liquid nitrogen. The liquid nitrogen and low temperature provide very effective de-sensitization of the material during mixing, and the liquid nitrogen is easily removed by evaporation to give the finished pyrotechnic mixture. In Phase II, being conducted at NSWC Crane, a cast-cure approach to processing is being developed. The cast-cure technology, borrowed from the solid-rocket industry, involves mixing the energetic solids into a paste or slurry with a liquid, curable polymer. The product slurry is then vacuum cast in molds prior to chemical curing to a final product. Both Phase I and Phase II processes virtually eliminate the use of VOC's in processing. We have estimated that for the production of a particularly important pyrotechnic system, magnesium-teflon-viton, the annual output of waste solvents could be as large as 40,000 gallons. The use of the VOC's in processing is also accompanied, of course, by the atmospheric release of vapors, either unintentionally or intentionally during drying processes. Funding for this project is being provided by the SERDP Program and by the Office of Naval Research.

Acid Recovery and Recycle

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Separation processes are being developed to demonstrate nitric and hydrochloric acid recycle in the Los Alamos Plutonium Facility. Acids will be removed from waste liquid streams to levels meeting or exceeding federal and state regulations on liquid effluents. Recycle acid will be reconcentrated sufficiently to be used for dissolutions, etc. in lieu of makeup acid. In addition to removal of acids in liquid waste, radioactivity will also be lowered by several orders of magnitude.

The separation processes utilize evaporation of acid solutions followed by either distillation or vapor-phase membrane separation to yield an extremely low-acid stream for disposal and a concentrated acid for recycle. The project includes development, construction and testing of process systems for the demonstration. A nitric acid test distillation column, a hydrochloric acid test evaporator, and a hydrochloric acid vapor-phase membrane separator will be tested experimentally to individually demonstrate facets of acid recycle. Full-scale systems will be installed to implement these processes. This work builds upon existing capabilities at Los Alamos for evaporating radioactive acid solutions in a glove box environment.

Recycling of Uranium- 6% Niobium Alloy via Electron Beam melting

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Due to a rather unique set of properties, uranium and its alloys have been found useful in a variety of applications, from nuclear-weapons components to counterweights in commercial aircraft. One such alloy of uranium and 6 wt.% niobium has been used for decades in applications requiring a relatively high corrosion resistance, which pure uranium does not possess. Using current production methods for U-6Nb, over 80% of the uranium going into the process ends up as non-recyclable scrap or as process waste. Approximately half of this is a direct result of the current multi-step melting procedure, which, in addition to being rather inefficient, creates substantial environmental, safety and health liabilities and results in high production costs. Currently, commercial U.S. producers and the various DOE and DoD productions sites generate many tons of low-specific activity uranium scrap each year. By utilizing a single step electron beam melting process, the waste generated can be reduced by 75%. It is estimated that in addition to the obvious gains in manufacturing efficiency, this process change will also reduce radiation-exposure levels to plant workers by about 30% due to the decrease in the amount of handling required. Further, the ability to recycle what is now scrap can reduce the requirement for virgin feedstock to zero for the foreseeable future by simply working down current inventories of stored scrap material. In 1993, LLNL retrofitted an existing, on-site, uranium-qualified vacuum processing system to an electron beam melting furnace. In 1994, LLNL added scrap feeding capability to this system, and demonstrated the ability to recycle chopped Y-12 plate scrap vial this technique. In-specification U-6Nb ingots up to 5.5" diameter and 24" long are now produced using this equipment. Future plans call for the development of a process to allow recycling low-grade uranium machine turnings to further reduce waste streams, and to modify the LLNL furnace to allow 8" diameter ingot production to better match DOE needs for the U-6Nb alloy. Additional work is planned to demonstrate the viability of this process to recycle uranium alloy anti-armor munitions and scrap form munitions manufacture. It is anticipated that technologies developed under this project will be transmitted to private U.S. manufacturers of uranium metal products for implementation at production sites. Funding for this project was provided in part by the Strategic Environmental Research and Development (SERDP) Program. This work was done under the auspices of U.S. DOE by Lawrence Livermore National Laboratory (LLNL) under Contract No. W-7405-Eng-48.

Contribution of Mixing to Formation of Nox in Gas Turbine Combusters

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Advances in performance and pollutant emissions in gas turbine engine combustors have historically occurred in relatively small steps indicative of an evolutionary process. To meet the performance requirements of future military engines and also achieve low emissions, revolutionary combustor concepts are needed that provide rapid mixing of the fuel and air. One revolutionary combustor concept evolved form an Air Force Office of Scientific Research 6.1 program, underwent design and fabrication on a Strategic Environmental Research and Development Program, and was evaluated on an Air Force Civil Engineering Pollution Prevention R&D project. The concept is referred to as the Trapped Vortex (TV) combuster, because the flame is stabilized in a cavity that is sized to trap a vortex. Rapid mixing of the fuel and air injected into the cavity control the performance and emissions characteristics of a TV combuster. A TV combuster is simple, compact, and does not require the complex and expensive type of diffuser and fuel nozzle hardware needed in current combusters. Initial tests with a TV combuster demonstrated an order of magnitude improvement in lean-blowout-limit, a 50% reduction in pressure drop, an estimated 1.5% improvement in SFC, a combustion efficiency of 99.8%, and a factor of 12 reductions from a typical value of oxides of nitrogen (Nox). Considerable work remains before the TC combuster concept is demonstrated for use in an engine but results to date indicate that significant improvements in performance and cost of military gas turbine combusters as well as reductions in emissions can be achieved. Although military gas turbine engines are exempt from the emissions regulations that govern commercial aviation, the Air Force policy, as stated in AFR 19-1, is to make a best effort attempt to comply with emissions regulations while maintaining high performance. The TV combuster offers the potential of developing high performance and low emissions gas turbine engines that is consistent with the stated Air Force policy. Cleaner aircraft engines will provide an emissions operating margin so that, as future air quality regulations become tighter and possible include military aircraft, air bases will not be penalized. Low emissions of Nox are driving commercial gas turbine engine development programs. Airlines are purchasing aircraft with engines that have the lowest Nox emissions. This reduces the risk of their aircraft not meeting future emissions regulations. Because the TV combusters has the potential of achieving of achieving low NOx, it is an excellent candidate for use in commercial as well as military aircraft.

Non-Chemical Surface Preparation

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State of the are surface treatments for aluminum and titanium alloys generate large amounts of wastewater within the process and/or incident to waste treatment. Treatment processes themselves required the use and handling of hazardous acids and bases. Furthermore, the increased emphasis on reduction of volatile organic compounds and air toxic emissions will dramatically increase the wastewater stream from surface preparation processes. Management, treatment, and disposal of these hazardous materials and wastes are increasingly costly, burdensome, and constantly attended by the risk of enforcement actions by local, state and federal authorities. The development of metal surface preparations that do not require the use of generation of the hazardous substances that will significantly aid the DOD in meeting its pollution prevention goals. This program will involve laboratory R&D, process scale-up, specifications development and technology transition in two specific technical areas. These areas are: 1) Radiant energy surface preparation of aluminum and titanium alloys. The feasibility of the use of the radiant energy to grow oxides on aluminum has ben shown, and the bondability to both coatings and adhesives has been demonstrated. The specific processes are ion beam enhanced deposition, plasma deposition and excimer laser oxide growth. 2)Non-Chemical surface morphologies for coating and bonding to aluminum, titanium and copper. These efforts are aimed at understanding the mechanisms of silane surface treatment of aluminum and developing the non-hazardous chemical surface treatment for titanium. Current results have shown good progress towards the development and understanding of cost effective alternative surface treatment technologies. The fully developed technology can be implemented in current DOD systems production as well as in depot maintenance activities. Aluminum surface treatments can be implemented in the commercial aircraft and automotive industries. Lead Agency: Wright Laboratory, Systems Support Division- POC Ted Reinhart.

Large Aircraft Robotic Paint Stripping (LARPS)

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The Air Force Air Logistics Centers primary method of removing organic protective coatings (paint and primers) from aircraft structures is with environmentally hazardous methylene chloride based chemical stripping compounds. The disadvantages of manual chemical stripping are: long processing time, expensive and hazardous chemicals, personnel exposed to hazardous environment, and special disposal techniques are required. Methylene chloride and other hazardous chemicals will be banned by the Air Force in 1997 and the Environmental Protection Agency or federal law by the year 2000.

LARPS is an automated, environmentally safe paint stripping system being developed by Wright Laboratory's Manufacturing Technology Directorate, Oklahoma City Air Logistics Center (OC-ALC) and Pratt and Whitney WJS to replace manual chemical stripping operations. Initially the LARPS system, which utilizes a high pressure water process, will be qualified to strip C-135 and B-1 aircraft and OC-ALC plans to extend the application of LARPS to include B-52 and E-3 aircraft. LARPS will reduce hazardous waste by 94% , eliminating the 135,000 gallons of chemical stripper annually, enabling OC-ALC to become more compliant with environmental directives and requirements. The LARPS system and ACS workcell are projected to save OC-ALC $4.6 M annually.

To date, the structural integrity of safety of flight thin skin aluminum aircraft structure has been shown to be maintained through months of testing and establishment of high pressure water process parameters. The testing of thin skin aluminum metal has resulted in approval by OC-ALC System Program Directors (SPDs) for use on C-135, B-52, B-1, and E-3 aircraft. B-1 specific composite materials are currently being tested with similar results expected by June 1995.

The LARPS robotic system will be the largest mobile robot in the world with unprecedented accuracy and repeatability. The robot hardware is currently integrated at the contractors facility with software and subsystem integration underway. To date, coordinated, simultaneous 9-axis movement of the robot system has been demonstrated. Validation testing of the system is scheduled for June 1995 at the contractor facility with shipping and installation at OC-ALC scheduled for August 1995. Stripping of the first C-135 is scheduled for June 1996.

Two additional contract changes were accomplished after the program was started. One was to produce an Aircraft Component Subsystem (ACS) for OC-ALC. The goal of the ACS is to provide automated high pressure water coatings removal on smaller components that are removed from the aircraft prior to stripping. The ACS will be used to remove paint from Maintenance Items Subject to Repair (MISTR) and regular Programmed Depot Maintenance (PDM) parts. Approximately 285,000 square feet of these components were stripped by OC-ALC in 1991. This is equivalent to 28 C-135s in total surface area. The largest part (of the 160 types identified) to be stripped in this workcell is the B-52 inboard flap at 31 feet 6 inches long by 8 feet 6 inched high. The workcell area itself (not including the operator of equipment rooms) is approximately 20 feet by 50 feet. The system was activated in October 1994. A successful

Large Aircraft Robotic Paint Stripping (LARPS) (cont'd)

Validation test was held at OC-ALC on 17-18 Oct 94 with operator training 14-18 Nov 94. The system successfully stripped several C-135 Flaps demonstrating semi-automated environmentally safe coating removal at stripping rates of 125 sq ft/hr, with no damage to the aircraft components and no hazards to ALC personnel.

The second contract change was to demonstrate high pressure water coatings removal process for use in a naval shipyard. This is a joint initiative with the US Navy which has developed a separate system for stripping of ships and submarines in a dry dock environment. The Navy waterjet demonstration system utilizes a completely different nozzle and overall system design that the Air Force LARPS system. The LARPS system utilizes a 4 inch nozzle designed to remove paint from thin skinned sensitive aircraft structure, while the Navy uses a 6 inch nozzle designed to remove very thick coatings from rugged steel surfaces. The Navy System is designed as a portable system with 100% recovery at the source, while the LARPS system requires a dedicated facility that recovers the paint chips and water through the floor. The Navy system was successfully demonstrated at Puget Sound Naval Ship Yard in Sep 94 with validation testing held in Dec 94 at Pearl Harbor. The system is performing exceptionally, demonstrating 100% recovery at the source with stripping rates from 100 - 175 sq ft/hr.

Monitoring the Constituents of the Upper Atmosphere

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The Atmospheric Remote Sensing and Assessment Program (ARSAP) applies environmental sensor and platform technology developed for national security programs to global environmental change. Naval Research Laboratory's (NRL) effort in ARSAP is concentrated on increased understanding of changes in the middle and upper atmosphere and utilizes satelite sensors developed for strategic defense or communications modeling. Data from these sensors will help to better document and understand ozone depletion and thermal changes in the upper atmosphere resulting from greenhouse gases and chloroflurocarbons of human origin. Results from this program include measurements of the global distribution of ozone, water vapor and the chlorine monoxide radical, of the altitude structure of the antartic ozone hole through an entire cycle, and of the geographic and altitude distribution of the hydroxyl radical in the mesosphere. Theoretical and computational capabilities have also been developed to compare experimental results to state-of-the-art 1-D and 2-D models of the straosphere and mesosphere.

New Technologies for Atmospheric Monitoring

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This program uses unmanned aerospace vehicles (UAVs) to make key climate measurements that cannot be made by other means. Because they are unmanned, UAVs have the potential for flying higher and longer than manned aircraft. This long endurance at high altitudes turns out to be an important capability when studying how clouds interact with the solar and thermal radiation balance of the atmosphere. By equipping the UAV with the proper payload and flying it at different altitudes, one can measure the rate at which heat is absorbed in the atmosphere or provide calibration for satelite-and ground-based remote sensors. When combined with ground-based measurements, these UAV-based measurements will help resolve one of the largest uncertainties in predicting "greenhouse warming": how clouds act to heat or cool the earth.

Given this potential for UAVs to make key climate measurements, our multi-laboratory team has undertaken a three-phase program to make this a reality. The first phase, completed in the spring of 1994, used an existing UAV, the General Atomics Gnat 750, and modified versions of radiometers originally developed for manned aircraft to make the first ever climate-relevant measurements from a UAV. Eight highly successful flights over the DOE's climate site in Oklahoma measured atmospheric heating under a variety of clear-sky conditions up to an altitude of 23,000 feet. The results constitute a unique data set for studying atmospheric heating.

Succeeding phases extend these capabilities through two major thrusts. The first develops compact, high accuracy, climate instruments specially designed for UAVs. Instruments to be completed this year include:

- a novel net flux radiometer for accurately measuring the difference between up and down-welling radiation;
- an imaging cloud radiometer for retrieving cloud reflectivity, determining whether the cloud is water or ice and what the effective droplet size is, and for calibrating various satellite measurements;
- a fully eye-safe lidar for detecting and profiling thin cirrus clouds which are difficult to measure by other techniques.

The second thrust takes advantage of increasingly more capable UAVs to extend operations to higher altitudes for cloudy sky measurements and satellite calibrations. Three major campaigns are planned through the end of 1996:

- a cloudy skies mission to directly explore the recently observed enhance shortwave absorption, which can have a major impact on our understanding of atmospheric heating;
- a long endurance mid-latitude tropopause mission (40,000 feet) to extend these measurements and to calibrate and validate satellite-based measurements;

New Technologies for Atmospheric Monitoring (cont'd)

- a high altitude (40,000-65,000 feet) mission to study cirrus heating and the role of upper tropospheric water vapor on the earth's radiation budget.

The ARM-UAV program is a multi-agency, multi-laboratory program. Sandia National Laboratories provides overall technical direction with key contributions from: Brookhaven, Lawrence Livermore, Los Alamos National Laboratories and Pacific Northwest Laboratory; NASA Ames, Goddard, and Langley Laboratories; Colorado State and Harvard Universities, Scripp's Institution of Oceanography and the University of Maryland.

Acoustic Monitoring of the Global Ocean Climate

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The oceans play a vital role in climate change, whether associated with greenhouse warming or natural variability. Climate models need to be tested against measurements if the model predictions are to serve as a basis for national policy.

Global warming is expected to be variable with typical spatial scales of 5,000 to 10,000 km. Acoustic transmissions can provide a very sensitive measure of temperature changes on this scale. Sound travels faster in a warmer ocean, and so the travel time between distant acoustic sources and receivers is a sensitive measure of temperature of the intervening waters.

In a November 1994 test, we transmitted signals from a source suspended near Jasper Seamount (300 miles southwest of San Diego) to a series of horizontal arrays of the Navy's SOSUS system distributed over the northeast Pacific Ocean. We also recorded the signals on two specially constructed vertical arrays, one moored north of Hawaii and the other off the California coast. A receiver off New Zealand at a range of 10,000 km also recorded the signal. The signals were well recorded; the travel time precision appears to be adequate for a sensitive measure of climate variability. Plans provide for acoustic sources off California and Kauai to transmit for one year to measure the seasonal variability in the northeast Pacific.

Multi-Spectral Multi-Platform Satellite Cloud and Cloud Environment Retrievals for SERCAA

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Determinations of cloud presence, properties, and radiative influence are high priority requirements for both defense related operations and the pursuit of research goals for the U.S. Global Change Research Program. An ongoing program to address these needs is the Support of Environmental Requirements for Cloud Analysis and Archive (SERCAA) program sponsored by the Strategic Environmental Research and Development Program (SERDP). SERCAA is a two phase basic research program to develop techniques for analysis of multi-source multi-spectral satellite sensor data for the purpose of estimating cloud fractional amount, location, height, and type. Data sources for this work include National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) and TIROS Operational Vertical Sounder (TOVS); Defense Meteorological Satellite Program (DMSP) Operational Linescan Sensor (OLS), Special Sensor Microwave Imager (SSM/I), temperature profiler (SSM/T), and moisture profiler (SSM/T-2); and geostationary imaging sensors. In the now completed first phase, separate cloud analysis algorithms were developed for each imaging sensor in order to best exploit the information content unique to the individual data sources. A major innovation was development of an analysis integration approach based on numerical weather prediction data assimilation techniques to combine the separate algorithm results from the temporally, spatially, spectrally inconsistent sources into a single logically consistent analysis. In the current, second phase, work has been expanded to include algorithms for retrieval and estimation of the cloud physical and optical properties such as phase, drop size distribution, optical thickness, and emissivity. Also under investigation are cloud environment parameters including vertical profiles of temperature and moisture available form sounding sensors. Other parameters of interest, such as surface temperature and cloud liquid water content, may be retrievable from the SSM/I.

Towards a Global Environmental Change Monitoring and Prediction System

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The rapid confluence of three technologies:

- High Performance Computing (HPC);
- Accurate Satellite Data (e.g., TOPEX/POSEIDON, etc.); and,
- Rapid improvements in our understanding of model and ability to the ocean and atmosphere now make it realistic and timely to consider the development and implementation of a global, numerically-based model designed to study the role of the hydrosphere (oceans + atmosphere) in Global Environmental Change. The System will be updated via its assimilation of both satellite and in situ oceanographic and atmospheric data.

A recent, highly visible, measure of the potential of such a system is provided by the study of Jacobs et al. (NATURE, 1994) in which the NRL Global Ocean Model and satellite altimetry are used to uncover the decade-long connection between the 1982 El Nino and anomalous warm upper ocean temperatures in the far North Pacific during the early 1990's. Such connections were previously unexpected and until recently, the means to "discover" them (i.e., the ocean models and the altimetry) did not exist.

The Global Change Monitoring and Prediction System will be particularly critical for studies on the seasonal to interannual timescales. Several specific Global Change issues best studied through the implementation of such a system include:

(1) El Nino monitoring and prediction;
(2) Study of the origin, dynamics, and predictability of observed multi-year anomalies in coupling between ocean and atmosphere;
(3) Study of the role of oceanic eddies including heat fluxes and transport and pollutant dispersion; and,
(4) The role of global ocean "Conveyor Belt" circulation in total Global Change budgets.

Additionally, such a system would allow for highly cost-effective simulations used to identify optimal arrays and data types for Global Environmental Change studies, monitoring, and prediction. Such design studies are now ongoing in collaboration with SERDP's ATOC tomographic projects. This work can ultimately lead to the development of a grand Global Environmental Monitoring and Prediction System which includes the Arctic and sea ice as well as coupled biological models focused upon the impact of Global Change on the Ecosystem.

Videos and state-of-the-art computer visualization will be used to quickly illustrate this exciting topic.

DMSP Digital Archive

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Our presentation will describe the DMSP digital data archive established at the NOAA National Geophysical Data Center (NGDC).

The DMSP mission is "... to collect and disseminate global visible and infrared cloud cover and other specialized meteorological, oceanographic and solar-geophysical data to support Department of Defense (DoD) operations ...". One of the SERDP objectives is "... to furnish other government organizations and private organizations with data, enhanced data collection capabilities and enhanced analytical capabilities for use by such organizations in the conduct of environmental research, including global and environmental change." The National Geophysical Data Center (NGDC) mission is to "... collect, disseminate, analyze and archive geophysical data ...".

Telemetry from all operational DMSP satellites are received at Air Force Global Weather Central (AFGWC). After initial processing, all scientific instrumental data are sent to NGDC, where the data are decommutated, deinterleaved, geolocated and where appropriate calibrated to physical units. Almost all missing data are rescued. Accurate satellite ephemeris are computed. Browse imagery are generated for on-line search, browse and selection functions. Image display, in situ data display, analysis tool and environmental parameter software developed with the Principal Investigators are available for distribution.

DMSP data are currently received from F-10, F-11, and F-12 satellites. F-10 crosses the equator at 2154 LT, F-11 crosses the equator at 1804 LT and F-12 crosses the equator at 2119 LT. Data from the following sensors are available from the archive:

F-10: OLS, SSM/I, SSM/T, SSJ/4 and SSIES.
F-11: OLS, SSM/I, SSM/T, SSM/T2, SSJ/4 and SSIES.
F-12: OLS, SSM/T, SSM/T2 and SSM.

Global Inventory of Biomass Burning (GIBB)

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The NOAA-National Geophysical Data Center (NGDC), in coordination with the U.S. Environmental Protection Agency, has initiated a Global Inventory of Biomass Burning (GIBB) with support from the Strategic Environmental Research and Development Program (SERDP). Biomass burning is the second largest anthropogenic source of greenhouse gas emissions, following fossil fuel consumption. In addition, biomass burning is a major source or tropospheric ozone precursors, compounds linked to stratospheric ozone depletion (methyl chloride and methyl bromide), and cloud nucleation aerosol particulates. By monitoring the spatial and temporal distribution of fires, the GIBB will produce annual estimates of trace gas and aerosol particulate emissions from fires. The GIBB products are designed to fill information requirements of the Intergovernmental Panel on Climate Change and the U.S. Environmental Protection Agency, Office of Policy, Planning, and Evaluation.

The GIBB project is being conducted using data from the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS). Methods for detecting active fires and estimating burn area are being developed for both daytime and nighttime OLS data. The nighttime detection of fires is accomplished using the visible / near infrared OLS band. The daytime detection of fires will rely on the thermal infrared OLS band.

Our presentation will cover the physics of fire monitoring using satellite sensors, the algorithms and databases being developed for the GIBB, examples from diverse regions of the world, current and planned collaborations with related programs, and the plans to transition the R&D effort to an operational civil agency program.

Land Cover Classification of the Chesapeake Bay Region

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The Landcover Classification efforts focus on assessing the value-added of National Technical Means assets when applied to challenging problems in the environmental communities, particularly the generation of improved quality and accuracy of landcover maps. High quality map data are foundation elements that support a variety of missions to monitor the status and trends of ecological resources, assess environmental contamination and clean up, evaluate the success of policies and programs, and identify emerging environmental problems. Specific applications to DOD sites include training area management, forest health monitoring, beach erosion, and pollution monitoring and control. The studies in this effort revealed that NTM, when added to standard Technical Means products available to the environmental community, contribute unique added value and can substantially improve the quality and accuracy of landcover classification. Completed studies of DoD sites, the Sykesville, Maryland area, and the Chesapeake Bay Watershed area have displayed an ability to not only enhance landcover categories in a limited area, but also to extend those signatures and classifications over entire landsat scenes more accurately, rapidly, and cost effectively than methods using TM data alone. Classified coregistered imagery stacks of TM and NTM data in addition to large quantities of ground truth data are provided on CD ROM in a PSR Hypermap capture and display tool. Environmental community customers will be provided unclassified derived products in the form of landcover maps as well as TM and ground truth data.

Browse and Access to the DMSP Digital Data Archive

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During the poster / exhibit session we will provide a computer demonstration of the on-line search and browse capabilities established for the Defense Meteorological Satellite Program digital data archive. In addition, we will demonstrate a series of scientific data viewers developed for the OLS, SSM/I, SSM/T, and SSM/T2 sensors of the DMSP.

During the past year we have made substantial progress in establishing browse products, on-line services, and data viewers to meet these two objectives. Our 1994 accomplishments along these lines include:

a. Sample images and applications shown on Mosaic (and Gopher) are averaging 145 external users per day , with an average of 1,300 image file accesses per day. DMSP files account for 75% of all of NGDC accesses on the World Wide Web.

b. OLS visible and infrared images are combined with a list of tropical cyclones prepared by the National Hurricane Center and made available through Internet via Mosaic, Gopher and FTP.

c. Procedures have been developed for filling data requests from the DMSP archive.

d. NGDC distributes image display software for viewing OLS, SSM/I, SSM/T, and SSM/T2. These viewers, available at no-cost, permit the display of DMSP on UNIX computer platforms using a point and click graphical user interface. The display software automatically performs an earth-curvature correction; permits users to select and view orbits; adjust brightness, contrast, color, and tint; display pixel values, longitude, latitude, and time; project the position of the current orbit and coverage area on a spherical outline of the earth; and overlay coastlines and national boundaries.

Fire Observation Using the DMSP Operational Linescan System

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During the exhibit session we will demonstrate the algorithms being developed for detecting active fires using data from the Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS). The SERDP sponsored Global Inventory of Biomass Burning (GIBB) is currently developing a capability for daily, worldwide fire monitoring and will use the fire observations to estimate trace gas and particulate emissions from biomass burning. The global monitoring of emissions from biomass burning is a key objective of the Intergovernmental Panel on Climate Change (IPCC) and the U.S. Global Change Research Program.

The nighttime detection of fires is based on the visible /near-infrared emissions of active and smoldering fires in the OLS "VIS" band (0.6 to 0.9 um). On-board light intensification of the OLS VIS band at night makes it possible to detect faint light sources present on the ground surface. For daytime and dusk detection of fires, we are investigating the use of the thermal infrared (10 to 13 um). Examples will be shown from Asia, Africa, Brazil, and the western USA.

Low Energy Model Installation Program

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Current energy policy requires federal and DoD facilities to reduce energy consumption and costs by 30% from 1985 to 2005, by implementing a variety of project and maintenance strategies, maximizing the use of alternative financing. The Energy Policy Act of 1992 requires that all projects that payback within ten years be completed by 2005. Successful implementation of these initiatives has potential savings of $700 million per year. Proper analytical tools and methodologies to ensure optimum implementation of the energy program have not been available. The DoD Low Energy Model Installation Program at Fort Hood, Texas, demonstrates the effectiveness of the comprehensive approach while acting as a testbed for the development and technical transfer of tools and methodologies. This project is a combination of applied research, technology demonstration, and technology transfer.

The Low Energy Model Installation Program has two technical objectives. The first is developing a generic methodology and tools for bringing an entire installation up to an energy efficient state. The second is to implement this methodology at a given installation for demonstrating and validating the process. The two efforts are being conducted simultaneously in a synergistic manner. SERDP is funding the methodology and tool development, project development, minor demonstrations, and project validation while leveraging other much larger funding requirements for projects.

Generic analysis tools have been designed to formalize and automate the methodology as much as possible. They provide the DoD and installations with a consistent method and yardstick for evaluating projects and progress. This program has enhanced PNL's Federal Energy Decision Screening (FEDS) model and CERL's Renewables and Energy Efficiency Planning (REEP) model which are used to determine the maximum potential and the environmental benefits of energy conservation in the DoD. LBL's End-use Disaggregation Algorithm (EDA) methodology has been used to develop the final tools that facilitate the process, the Installation Baseline Energy Analysis Model (IBEAM) and the Building Use and Characterization System (BUCS).

Historically, new technology has had an extremely slow penetration into the DoD infrastructure. Typical lag times are up to fifteen years. Demonstrations conducted under this program at Fort Hood are intended to overcome these obstacles and show all parties that the current paradigm needs adjustment and that new technology will benefit the installation and the national infrastructure as a whole from both the energy and maintenance perspectives.

Natural Gas Based Air Conditioning Demonstration

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In an effort to reduce cost and environmental impact of operating air conditioning equipment at Army Installations, the US Army Construction Engineering Research Laboratories (USACERL) have been investigating gas cooling technologies for several years. Air conditioning requirements at DOD facilities typically occur when the electric rates are the highest. The demand portion of an installation's electric bill can exceed 50% of the total bill. State-of-the-art natural gas fired cooling systems, such as absorption chillers, engine driven chillers and desiccant systems, can be used to reduce the environmental impact and operating cost of cooling equipment, as well as avoid the use of environmentally harmful refrigerants. Hospitals, barracks, and other DOD facilities where large cooling and hot water loads exist are prime candidates for gas cooling technologies.

Recognizing this fact, Congress has provided a total of $19.25 Million over several years to the DOD for "natural gas chillers for the air conditioning of Department of Defense facilities". This money is split equally between the Army, Air Force and Navy. USACERL is implementing the gas cooling programs for the Army and the Air Force.

In support of these projects, DOD and the Strategic Environmental Research and Development Program (SERDP) have provided USACERL additional funds to identify and evaluate potential implementation sites, develop the equipment purchase documentation, supervise equipment installation and acceptance, monitor equipment performance, and document lessons learned to assess the applicability of these technologies within the DOD as a whole.

This paper will discuss the background and purpose of the Congressional gas cooling funding and show how SERDP funding is being leveraged to help identify and implement gas cooling projects in DoD, as well to evaluate the overall environmental, technical and economic benefits of these technologies.

Advanced Cycle Mobile Heat Pump

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A field depolyable environmental control unit (ECU) using non-ozone depleting refrigerants is needed to minimize environmental damage which can occur as a result of an inadvertent release of CFC/HCFC refrigerants into the atmosphere. The Clean Air Act requires that certain CFCs be phased out by the end of 1995 and HCFCs by 2004, which creates a requirement for researchers to develop a new generation of ECUs that can use non-ozone depleting refrigerants.

The new generation of ECUs will have higher energy efficiency, be compact, and use non-ozone-depleting refrigerants. To achieve this objective, Air Force research has shifted from finding new non-CFC/HCFC refrigerants for the compression cycle to developing new thermodynamics cycle concepts. Three concepts are being investigated, with the most successful one to be selected for further development. The first concept is the thermoelectric heat pump. It works on the Thomson-Peltier effect. When a voltage is applied on a circuit made of two conductors a temperature difference between the two junctions is created. Current thermoelectric heat pump technology is bulky and inefficient but it is simple, has no moving parts, and does not use refrigerants. To design an efficient and compact unit, work in this area is concentrating on finding new semiconductor materials that have high Seedbeck and Peltier coefficients combined with low electrical resistivity and low thermal conductivity and expansion. The second concept is the high temperature superconducting magnetic heat pump. This concept works on the magnetocaloric effect where the thermodynamics cycle operates near the Curie temperature of the magnetic medium material. When a magnetic field is applied, the magnetic energy is transferred into thermal energy heating the material. When the applied field is withdrawn the material is cooled due to the random orientation action of its internal domains. The magnetic field strength required in heat pumps is typically several Telsa (6-10 T). Using normal conductors at that strength makes the heat pump bulky and heavy. However, existing high temperature superconducting magnet technology should allow the design of an efficient and compact heat pump. The third concept is the pulse tube heat pump which works on thermoacoustic effects. Using a linear resonant compressor to oscillate the working fluid over stationary, equally spaced solid plates (regenerator), a cold and a hot end are maintained with the hot end closest to the compressor. This is a new technology that uses inert gas as a working fluid and has a strong potential to become an efficient and cost-effective heat pump.

A prototype of the most promising concept will be fabricated and tested for performance. The technology will be transitioned to advanced development and production. The fielded unit will be environmentally safe, compact, operable under a variety of adverse wartime conditions, and require less logistical support.

Fuel Cells for Military Applications

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The supply of reliable, cost-effective electric power with minimal environmental impact is a constant concern of Department of Defense (DOD) installation energy personnel. Since the majority of central heat plants on U. S. military installations are nearing the end of their useful life, there is an opportunity to replace outdated existing equipment with modern technologies.

Fuel cells are electrochemical power generators with the potential for attaining very high electrical energy conversion efficiencies while operating quietly with minimal polluting emissions. In addition, by-product thermal energy generated in the fuel cell is available for use for cogeneration of hot water or steam. Phosphoric Acid Fuel Cells (PAFCs) are currently entering the initial stages of commercialization. At the present time, PAFCs are not economically competitive with other more conventional energy production technologies. However, current cost projections predict that PAFC systems will become economically competitive within the next few years as market demand increases.

The FY 1993 Defense Appropriations Act provided $6.0M worth of equipment procurement funds per Service for the implementation of "non-developmental item natural gas fuel cells currently in production in the United States...for power generation at military installations...". The FY 1994 Defense Appropriations Act provided an additional $6.25M worth of equipment procurement funds per Service "to continue procurement of...200 kW phosphoric acid natural gas fuel cells...". The purposes of this demonstration project are to stimulate growth in the fuel cell industry, which will lower costs through economies of scale and competition, and to determine the role fuel cells should play in DOD long-term energy supply strategy. USACERL was requested to coordinate this fuel cell demonstration program for all three Services.

A total of 12 200-kW turnkey PAFC Power Plant packages were purchased with the FY 1993 Appropriations and are in the process of being installed at DoD installations. These turnkey packages include purchase, site engineering, installation and startup, operation and maintenance training, and a five year warranty, maintenance and repair period. A solicitation has been prepared to continue this procurement with the FY 1994 Appropriations. Performance of all units purchased and installed will be monitored for a five year period. Funding for this project is provided by the Strategic Environmental Research and Development Program (SERDP).

Photovoltaics for Military Applications

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DoD is the largest single user of energy in the United States. Many remote DoD missions are dependent on reliable energy; and the high cost of operations and the environmental degradation reflect this dependence. Photovoltaics can substantially reduce these costs and increase mission security at the same time. PV's long-term potential for cost-effective applications within the DoD is estimated at nearly 3830 MW of installed electrical capacity, which translates to about 33% of the energy consumed in the form of electricity. If fully implemented, PV could reduce emissions and the dependence on fossil fuels by about 33% and save on the order of $1580M/year, as compared to the current emissions and costs of facility electricity.

DoD's Photovoltaic Review Committee (PVRC) has developed a master Strategy to realize the full potential of PV. The application base is categorized into three main areas: Small stand-alone (50,000 systems of less than 25 kW for about 50 MW installed capacity), Intermediate/Large Remote (3,900 systems between 25-1000 kW for about 420 MW installed capacity), and Grid Interactive (3,100 systems greater than 500 kW for about 3350 MW installed capacity). The small stand-alone market is mature and cost-effective now. Prior to the SERDP program, the Intermediate Remote area was stagnant, even though the applications were cost-effective, because the required power processing hardware was not available. The PV for Military Applications project provided the necessary research and development, and as a result, there are now seven (7) systems, representing nearly 940 kW installed electrical capacity, under implementation as Military-Construction projects. Each of these systems have 20-year discounted savings of 2.5 to 3.5 times their investment and will increase mission security at the same time. In September 1994, the PV for Military Applications project awarded a contract for a system at Superior Valley, China Lake, CA, to evaluate hardware developed and tested for the Large Remote area and will, by June 15, 1995, award a contract for a system at Yuma Proving Grounds to address the first phase of the Grid Interactive area. The PV for Military Applications project, by providing the critical research and development effort required to enable the DoD application areas, will in effect reduce the time required to realize the benefits offered by PV (33% reduction in emissions and savings of $1580M/year) by as much as thirteen years.

The benefits of this program extend outside the DoD as well. The program will provide a means to apply advanced technologies from the DOE PV program, expand the application base for U.S. products, and enhance the capability of the U.S. industry to service these applications. These technologies and applications will also have direct application and leverage to other government agencies, including the National Park Service and National Forest Service. For example, the National Park Service has surveyed all their diesel generators and has identified substantial potential for cost, and environmental savings through PV.

Methodology for Determination of Life-cycle Impacts

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Methodology has been developed to enable the rapid and accurate comparison of cost and environmental impacts of photovoltaic (PV) and conventional power production technologies. The methodology uses computer software which operates on personal computers (PCs) with Microsoft Windows. The software, called GloTech, was designed by the U. S. Environmental Protection Agency (EPA) to compare the impacts of technologies and modified by this project to be useful for life-cycle analyses. GloTech enables the user to select information from databases resident within the software and to change or add data as appropriate. Impacts for many technologies such as PV power production and the use of diesel generators used to produce electricity at remote locations are automatically grouped and accessed using icons selected by the user of the software. The user then links the icons with other process icons as appropriate to assemble a process network. After the assembly is complete, the software calculates the total cost and environmental impacts such as releases to the air, water, and land. To assure a clear data pedigree, reference and note fields are associated with each piece of information and the user updates the reference as changes are made. This new software has several important applications for the military. First, it allows for comparison of the true "cradle-to-grave" impacts of power production technologies that are applicable to remote locations. Some impacts such as the fate of toxic materials associated with production and disposal of electronic equipment and fuel spills in the operation of fuel-driven devices are not immediately obvious and are frequently not considered prior to selection of the technology to be employed. Further, it is useful for preparing environmental impact statements and other documents relating to the selection and implementation of technologies. The user-friendly, computerized format allows the information to easily be updated so that current information is always available and several parallel scenarios can be constructed for comparison. Funding for this project was provided by the Strategic Environmental Research and Development Program (SERDP). It is a sub-task under the SERDP project "Photovoltaics for Military Applications," and work is being performed in conjunction with the United States Department of Energy, Sandia National Laboratories. Information for population of the software was compiled using data from actual military applications where possible.

Use of Biomass Technologies on Military Installations: Demonstration of a Small Biomass Power Plant

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Utilizing biomass as a fuel for electric power generation eliminates sulfur dioxide emissions, produces zero net gain of carbon dioxide (CO_2), reduces air toxic emissions, and helps solve waste disposal problems. Power generation from biomass also avoids landfill tipping fees for biomass disposal, eliminates the purchase of fossil fuels, and provides an independent electrical source and increased energy security. EPA and DOE biomass energy projects are intended to provide the impetus needed for the development of equipment, design of systems, creation of markets, and promotion of exportable technologies.

Converting biomass to power at military installations supports DoD's objectives to support renewable energy thrusts (Energy Policy Act of 1992), provides energy security by installing locally fueled electricity generating units (DoD Instruction 4170.10), and meets waste reduction goals (Marine Corps Environmental Campaign Plan). The project (Camp Lejeune Electricity from Wood -- CLEW) is also a contribution toward meeting Federal directives to stabilize CO_2 emissions at 1990 levels by the year 2000, and to reduce Federal agencies' energy consumption by 20% below 1991 levels by the year 2000 (Executive Order 12759). The project has excellent potential for technology transfer to other public agencies and the commercial sector. This follows a trend of revived commercial interest in wood energy, and independent and distributed power production.

This project will demonstrate the technical, economic, and environmental feasibility of an innovative energy conversion technology, producing approximately 1 MWe, at the Marine Corps Base, Camp Lejeune, NC. Camp Lejeune has selected the site and will provide the biomass fuel from base maintenance activities, the utilities, and the operators. The technology selected produces a low-Btu gas from a downdraft wood gasifier to fuel reciprocating engines. Waste heat recovery is used for wood drying and improves conversion efficiency. Commercial operations at this scale can also incorporate cogeneration from waste heat recovery. This will be addressed by simulation to be incorporated in the overall commercial system design.

Technology selection, final design, fabrication, on-site installation, and shakedown are planned for the first two project years. Long-term testing and final operation status will be achieved in the third and final year. The project will be analyzed and documented, including equipment and system design; installation procedures; operational performance and efficiency; solid, gaseous, and liquid emissions and other environmental factors; and economics related to investment and O&M costs. Demonstration results will be compared with other available, small-scale technologies, including diesel fuel and gasoline-operated generators, and package boilers (wood, coal, oil, gas). The facility will remain on the site, operated by Base personnel, with connection into the local electrical grid.

Use of Biomass Technologies on Military Installations: Demonstration of a Small Biomass Power Plant (cont'd)

Funding for this project is provided by the Strategic Environmental Research and Development Program. This work is done with the cooperation of the U.S. Environmental Protection Agency's Air and Energy Engineering Research Laboratory, the Marine Corps Base at Camp Lejeune, the Research Triangle Institute, and the North Carolina Department of Commerce's Energy Division.

Geothermal Space Conditioning for DoD Buildings

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Annually, DoD spends billions to provide heating, cooling and water heating in its buildings. These expenditures, including facility HVAC energy, maintenance and replacement costs, represent an ever increasing burden for DoD during tight budgets. In addition, DoD is required to reduce energy consumption 30 percent by the year 2005.

Expanded use of geothermal heat pumps (GHPs) for both residential and larger DoD buildings has the potential to save DoD in excess of $300 million annually in energy, maintenance, and capital costs. GHPs use the ground as a heat source or sink for heating, cooling, and water heating often eliminating boilers and cooling towers for larger buildings. These systems are energy efficient, clean, environmentally friendly, and operate at a substantially reduced cost from conventional systems. The Environmental Protection Agency, in a recent report, stated that GHPs are the nation's most energy efficient residential HVAC system.

Through the Strategic Environmental Research and Development Program, $2.5 million has been committed to develop a permanent DOD capability to evaluate, design, install, operate, and maintain GHPs in buildings of all sizes nationwide. The program, started in FY 1993, has installed GHPs at various new DoD sites, is monitoring GHPs at a number of sites for energy and maintenance benefits, and working with additional bases to design and install GHPs.

The largest GHP project in the Nation is at Fort Polk, Louisiana where a shared energy saving contract has been signed to replace the HVAC system in over 4000 residences. This eliminates the need for the Army to seek nearly $20 million in appropriations for this major project and has shifted all maintenance to the contractor for 20 years. A major SERDP activity is to obtain statistically valid data on the energy and maintenance savings at Fort Polk. Based on current SERDP funding plans the effort to expand GHPs to larger DoD buildings will be limited. Design assistance will be provided in a few instances at new facilities such as Fort Leavenworth, however the opportunity to demonstrate replacement of existing boilers and cooling towers will not be funded due to a lack of funds.

Nationally, the Department of Energy is working with industry to sponsor a $100 million Geothermal Heat Pump Consortium to greatly expand the use of GHPs. The goal of this program is to increase sales of GHPs tenfold over the next six years to about 400,000 units annually. The utility industry is committed to match the Federal contribution on a two-for-one basis.

Fishing Enforcement/Whale Monitoring Using the Integrated Undersea Surveillance System

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Since 1990, scientists and engineers have been granted access to the Navy's Integrated Undersea Surveillance System (IUSS), of which the most well-known component is the Sound Surveillance System (SOSUS). Many details of the system's configuration remain classified, so work has largely been performed under secure working conditions at Navy or contractor facilities.

SERDP has supported ground breaking work using the IUSS, in particular the experiment known as "WHALES 93", in which Atlantic whales were monitored using the entire Atlantic SOSUS network. Many thousands of detections were made from several SOSUS arrays, principally blue whales, fins, humpbacks, and minkes. Two years of data were recorded before the Naval facility at Bermuda closed in November 1994, and analyses to date have focused on methods to separate and correlate multiple signals to arrive at population estimates.

Another major effort supported by SERDP focused on detection of drift net fishing vessels in the Pacific Ocean. Now banned,drift net vessels numbered as many as 2,000 ships and inflected terrible damage on sea life. Using the SOSUS arrays, researchers have identified acoustic characteristics of drift net activity that opens the way to remote detection and prosecution of illegal drift net fishing.

Terrain Modeling and Soil Erosion Simulation

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Soil erosion with subsequent siltation in streams and reservoirs has been a major environmental concern on military installations where intense training and testing activities cause severe recurrent disturbance to the soil surface. To assist in maximizing availability of military lands with minimal impact to natural resources, especially to soil and vegetation, advanced methods to model and analyze the spatio-temporal distribution of erosion and deposition are being developed. As a basis for successful erosion modeling significant effort has been devoted to the development of multivariate spline interpolation methods which facilitate accurate terrain modeling and analysis, as well as processing of rainfall, sediment, and soil measurements in 3-dimensional space and time. New, physically based methods for analysis of long term spatial distribution of high erosion risk areas and depositional locations are being developed using the unit stream power theory. Methods for rainfall/runoff and sediment transport simulations are being developed to allow modeling of sediment movement during the storm events. Modeling effort is supported by the development of new visualization techniques supporting the design and communication of models of dynamic processes and the methods are integrated within GRASS GIS to facilitate fast technology transfer. Several examples of terrain modeling and erosion/deposition risk assessment on military and nonmilitary lands illustrate the successful applications of methods and tools developed in this project.

Threatened, Endangered, and Sensitive Resources

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The growing numbers of threatened, endangered, and sensitive species (TES) on military lands increasingly result in: (1) mission constraints and impediments to land acquisition, potentially leading to reduced defense readiness; (2) lengthy and costly litigation; and (3) criminal and civil penalties. Major objectives of this research are to continue efforts to develop and evaluate approaches, methodologies, and techniques to assess and manage TES habitats, assess impacts of military activities on TES and their habitats, and to mitigate the effects of Army-unique impacts. Specific technical objectives are to: (1) develop regional guidelines for TES habitat evaluation and management; (2) develop models of impacts of smokes, obscurants, and tear gas agents on TES; and (3) evaluate approaches, methodologies, and techniques for enhancement of TES plant populations.

Regional habitat evaluation and management guidelines are being developed for one region addressing up to 60 species of plants and animals. We are defining habitat requirements for each species based on existing literature and coordination with species experts. Management strategies will be developed that apply collectively to species with similar habitat requirements. Plant population enhancement approaches will be evaluated for use by installation managers and specific guidelines will be demonstrated. Small-scale field and greenhouse studies are planned. Impact of smokes, obscurants, and tear gas agents are being evaluated with respect to plants and animals. Up to two species will be selected for detailed study based on risk assessment. A conceptual model will be developed for evaluating such impacts. Recently developed field research protocols will be applied and evaluated on a small scale.

These efforts will contribute substantively to a comprehensive, systematic, and integrated approach to TES management on military lands. Resulting products will support the Army's environmental and endangered species management strategies, and aid in efficiently meeting TES policy and regulatory requirements. Through this effort, the military will develop and demonstrate scientific and technical leadership in the management of TES. We will thus be better able to integrate TES considerations with military activities and avoid unnecessary mission constraints. Expected return on investment is high. On-going interagency coordination will yield benefits at national, regional, and local levels. Potential users include Army and other military elements at installation, major command, and headquarters levels who are responsible for TES management. Products will also transition to interagency and private sector partners.

Effects of Aircraft Overflights on Birds of Prey

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The public continues to raise concern over the possible effects of noise resulting from military low altitude aircraft. Even though some research has been accomplished in this technical area, conclusive results have not been documented. The Air Force has developed, through meta-analysis, an interim dose- response model to predict the effects of aircraft noise on raptors, but this model has not been tested. The current research tests the Air Force model. Our approach is to examine the effects of military low-altitude aircraft overflights on Peregrine Falcons, Bald Eagles and other raptors in the Yukon Military Operating Area, Alaska. The result of flights performed during a three day test in 1994 over one Peregrine eyrie demonstrated that the aircraft appeared to have little effect on the adults. Results of this pilot test and plans for this year's tests will be presented.

Assessment and Management of Risks to Biodiversity and Habitat

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Biodiversity, in its simplest terms, is the variety of life and its processes. It can be considered in terms of genetic diversity, populations, species, and habitats. The multiagency Biodiversity Research Consortium (BRC) is developing strategies to assess and manage biodiversity within a hierarchy of scales. These scales range from large, regional (or national) for prioritizing resource allocation to landscape or local for specific site management. Examples are given for Oregon for prioritization and for Camp Pendleton for site management.

In Oregon, we have developed algorithms for the determination of priority areas from biogeographic data using the mathematical tools of combinatorial analysis and simulated annealing. These techniques are designed to determine the most important locations for further investigation of biodiversity. Unexpected spatial patterns appear in this analysis showing that a relatively small number of sites must be investigated initially. We also show that prioritizing using one taxon may "sweep" along the diversity of other taxa, and that knowledge of some groups may sometimes make up for a lack of knowledge of others.

The Marine Corps Base at Camp Pendleton is situated between two large and fast growing regions: the Los Angeles area to the north and San Diego to the south. In the region surrounding Camp Pendleton, land development as well as natural pressures (e.g. fire and flood) threaten the natural and cultural resources of the facility, affecting habitat and, consequently, biodiversity. The research further shows how alternative futures scenarios involving urban growth and change from 1900+ to 2010 in the region will impact the hydrology, habitat conditions, and biodiversity of the Base.

Blood Protein Adducts of 1,3- Dinitrobenzene (DNB) as Biological Markers of Exposure

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Verification of exposure is a critical element in developing meaningful ecological risk assessments for environmental chemical contaminants. In this study we have investigated the utility of macromolecular adducts (e.g., blood protein and DNA adducts) of nitroaromatic munitions chemicals to serve as biological markers of exposure. DNB, an environmental contaminant detected at Army installations and superfund sites, was administered to rodents and the blood protein and soft tissue DNA adducts were quantified. Experimentally, sixty rats were orally intubated with [14C]DNB (0.178 m mol/kg, 65.4 mCi/m mol). Groups of five animals were killed after 0.33, 1, 2, 3, 4, 7, 14, 21, 28, 42, 56, and 70 days and the DNB adducted to blood proteins, including albumin (ALB), globulins (GLBU), and hemoglobin (HB) were determined. Formation of ALB, GLBU, and HB adducts were maximum at 8 hours, (53, 7.2, and 281 picomoles/mg protein, respectively), and decreased with time. About 90% of the ALB and GLBU adduct were cleared within a week while HB adduct persisted (e.g., 2.5% HB adduct were intact after 6 weeks). Blood protein adduct levels were increased several-fold when DNB was given daily (0.178 m mol/kg) for 7 days. Thus, protein adducts may be useful as markers for ecological exposure assessment. (This abstract does not necessarily reflect USEPA or US Army policies.)

Genetic Diversity Monitoring in Plants and Wildlife
The Brown Bullhead Catfish as a Model System

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Changes in population genetic diversity can be a sensitive indicator of environmental impact, since limiting the effective breeding population by any means will result in a loss of some variant genotypes. We have applied DNA fingerprint techniques to the analysis of genetic diversity in three populations of brown bullhead catfish. These were collected from two ecologically impacted inland waterways, the Black and Cuyuhoga rivers in northern Ohio and one reference site, Old Woman Creek.

We explored two methods of fingerprinting. In the first, genomic DNA isolated from fish red blood cells was digested with restriction endonucleases, southern blotted and probed with a labelled M13. In the second protocol, a variation on the polymerase chain reaction (PCR) known as Randomly Amplified Polymorphic DNA (RAPD) was employed with the same samples of brown bullhead genomic DNA. Ten base oligonucleotide primers were used and the amplified products electophoresed. In both methods bands that were produced were visualized and analyzed for polymorphisms to determine the degrees of similarity among and within the three populations.

Phased Array Ultrasonic/Acoustic Detection of Artifacts

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Once a cultural or archeological resource site is identified it must then be assessed for significance. A Phase II eligibility assessment for the National Registry of Historic Places (NRHP) typically costs $10K to $30K per site and involves significant physical labor. In the Army alone there are approximately 120,000 archeological sites of which only 10% have been assessed and the significance of the site determined.

The goal of this work is to develop a device using ultrasonic/acoustic sound waves for the sub-surface detection and imaging of artifacts. Sound waves exhibit the non-destructive capability of being able to be transmitted into and through the ground. These waves can be used to probe beneath the surface by being reflected off of mediums of higher relative density (i.e. bone, ceramic, stone, glass). Once reflected the return signals are then detected. A phased array approach for introducing and detecting the signals is anticipated. By varying each transducer's time delay and input amplitude the focused probe can be steered to examine successive control volumes beneath the surface. Reflected signals are then detected and through computer imaging and enhancement the location of possible artifacts can be identified while also gaining information about their shape and dimension. Compared to methods employing ground penetrating radar this acoustic approach promises to have a greater capability in the moist to wet environments which are often found in soils.

The main benefit from this work will be to significantly reduce the cost of data recovery at sites with unknown probability of significance. In addition, this method will be useful in avoiding unanticipated discoveries and project delays during construction and as well complying with the requirements stated in the Native American Grave Protection and Repatriation Act (NAGPRA). Potential also exists in the areas of underground utility location and the detection of unexploded ordnance.

A Computer-Based Information System for the Management of Noxious and Nuisance Vegetation

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There are many species of noxious and nuisance plants that cause serious problems for military installations across the country. Problem plants include the terrestrial species knapweed, leafy spurge, various thistles; and the aquatic/wetland plants water hyacinth, water lettuce, hydrilla, Eurasian water milfoil, purple loosestrife, among others.

Fortunately, there are many acceptable strategies for their control. For example, traditional strategies mainly involve the use of chemical applications and mechanical procedures. Such strategies allow for relatively rapid but short term solutions for the management of many terrestrial plant species. Alternative methods mainly involve the use of biological control methods such as the introduction of host-specific insect agents and fungal pathogens. In most cases, biocontrol technology allows for long term suppression of many species of noxious plants.

In order to effectively utilize each type of control option a variety of information is required. For example, with literally hundreds of different herbicide and adjuvant combinations available, effective utilization requires detailed information on use restrictions, the influence that environmental conditions have on control, state specific restrictions, etc. Operational personnel are faced with the identification of many species of herbivores that have been introduced to manage noxious plants. In addition to the agents themselves, an understanding of the agent's feeding preferences and damage type are also important. The development of an overall noxious plant management program is dependant on the ability of operational personnel to effectively and rapidly access pertinent information on the management of noxious and nuisance plants.

A fully functional, first generation, computer-based information system was developed under the Department of Defense's Strategic Environmental Development Program (SERDP) during FY94. Theinformation system uses a variety of techniques for rapidly and efficiently accessing a wide range of information on 18 selected noxious and nuisance plant species. The system is PC-based, and operates under Windows 3.1. The utilization of the Windows platform ensures high portability allowing it to run under many different hardware configurations. Information contained in the completed first generation system includes plant identification strategies, chemical control options, and information on available biocontrol agents. For each section, large quantities of textual information are included as well as numerous illustrations and photographic quality images. The system is highly interactive and in many cases simulates closely the interaction between experts and non-technical personnel. The system allows users instant access to a wide range of pertinent information on noxious and nuisance plant management strategies.

Marine Mammal Health

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The Department of Defense (DoD) uses estuaries, bays, harbors, and other water systems that it shares with marine mammals, the most legally protected, high profile biological resource with which DoD must deal. Recent mass cetacean die-offs in these habitats have, in some cases, been blamed on military exercises (c.f. Simmonds Lopez-Jurado, 1991). High levels of organochlorines (OCs) occur in these mass mortalities. DoD has a unique marine mammal program maintained by the Navy including a force of bottlenose dolphins, and expertise for studying these contaminants. This study supports the conservation thrust area of the Strategic Environmental Research and Development Program (SERDP) that focuses on research and development for understanding, protecting, and maintaining biological resources using technology and expertise of DoD, and scientific proposals that "marine mammals in captivity should be used to obtain a set of reference data to interpret values obtained from animals expected to be affected by contaminants (c.f. Reijnders, 1988)." With SERDP support, we have begun to analyze samples from current inventory that includes >950 milk, blood, and tissue samples. Using microsamples, gas chromatography, and mass spectrometry (GC/MS), we have quantified 25 PCBs using congener-specific analysis and 19 chlorinated pesticides with traceable calibration checks and practical quantitative limits of 0.3 ppb wet weight. For inter-laboratory comparison, a NIST blubber standard (SRM 1945) was part of our quality assurance program under the auspices of (NOAA), National Status and Trends Program and the EPA's EMAP. Quatitation of lipids using gravimetric separation in petroleum and ethyl ethers with the Roese-Gottlieb procedure (AOAC 1980) has allowed for lipid normalization of data. Lipid values were quantified for several stages of lactation, varying from 18-33% (Ridgway et al. 1995). To define the rate and route of OC transfer from one generation to the next, we analyzed milk samples. The highest values in ppm wet weight for DDE and tPCB were 10.2 and 4.45, respectively (Ridgway and Reddy 1995). As an initial step in assessing health-compatible budgets and baseline values of organochlorines we measured serum concentrations of circulating adrenal and thyroid hormones using radioimmunoassay (St. Aubin et al. 1995). We have also developed protocols for generating monoclonal antibodies against cetacean lymphoid cell surface markers for the immune assessment of cetaceans. These historical and environmentally crucial scientific studies depict DoD as a good steward of the oceans and coastlines it uses. This project is an efficient peacetime use of the Navy's marine mammal resources and expertise. The project has already involved the scientific coordination of several governmental agencies in addition to DoD including: EPA, NMFS, NIST, AFIP, and USDA. The expertise and data acquired through this project can be used to evaluate the effects of DoD operations, possibly prevent or defend against lawsuits, and provide data unavailable elsewhere for use in the government's forensics investigations of environmental contamination.

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